Reference Sites, Predictive Models, and Tolerance Values

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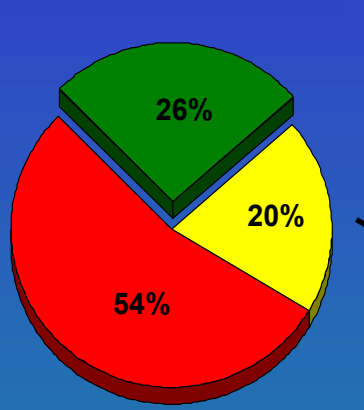
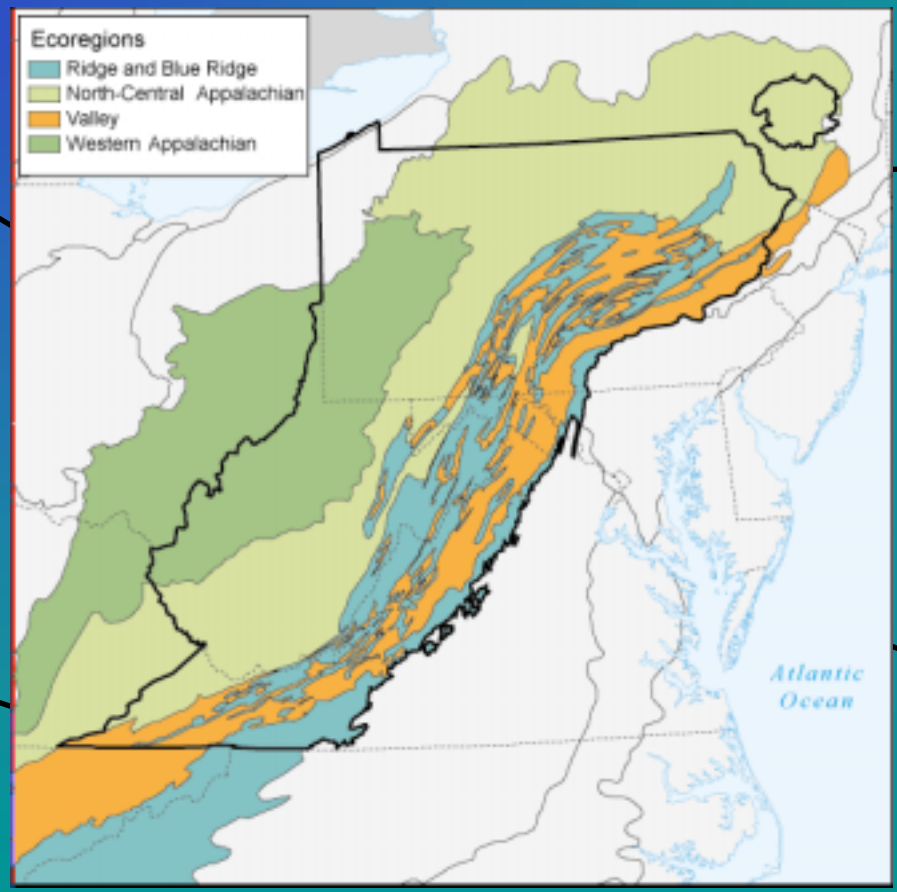
Presentation Overview

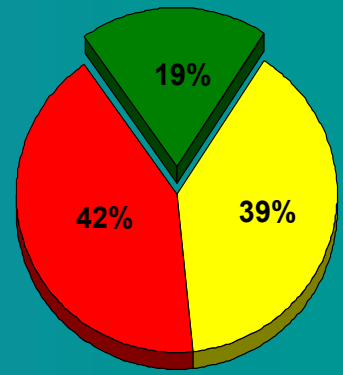
- **Reference Sites**
  - Rationale of Using Reference Sites
  - Definitions
  - Site Selection
  - Screening Process
  - Establishing Thresholds
- **Predictive Models**
- **Tolerance Values**
- **Relative Risk**

MAHA Results: Fish Index of Biotic Integrity Regional Patterns

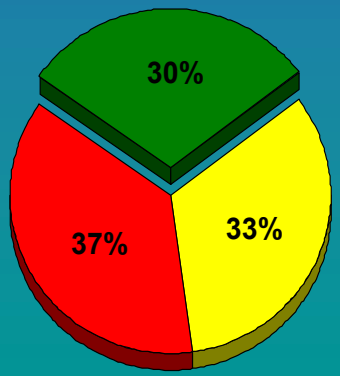


Western Appalachians

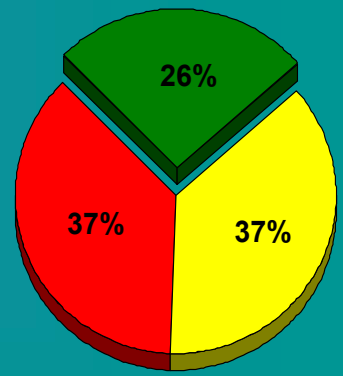




North-Central Appalachians



Valleys

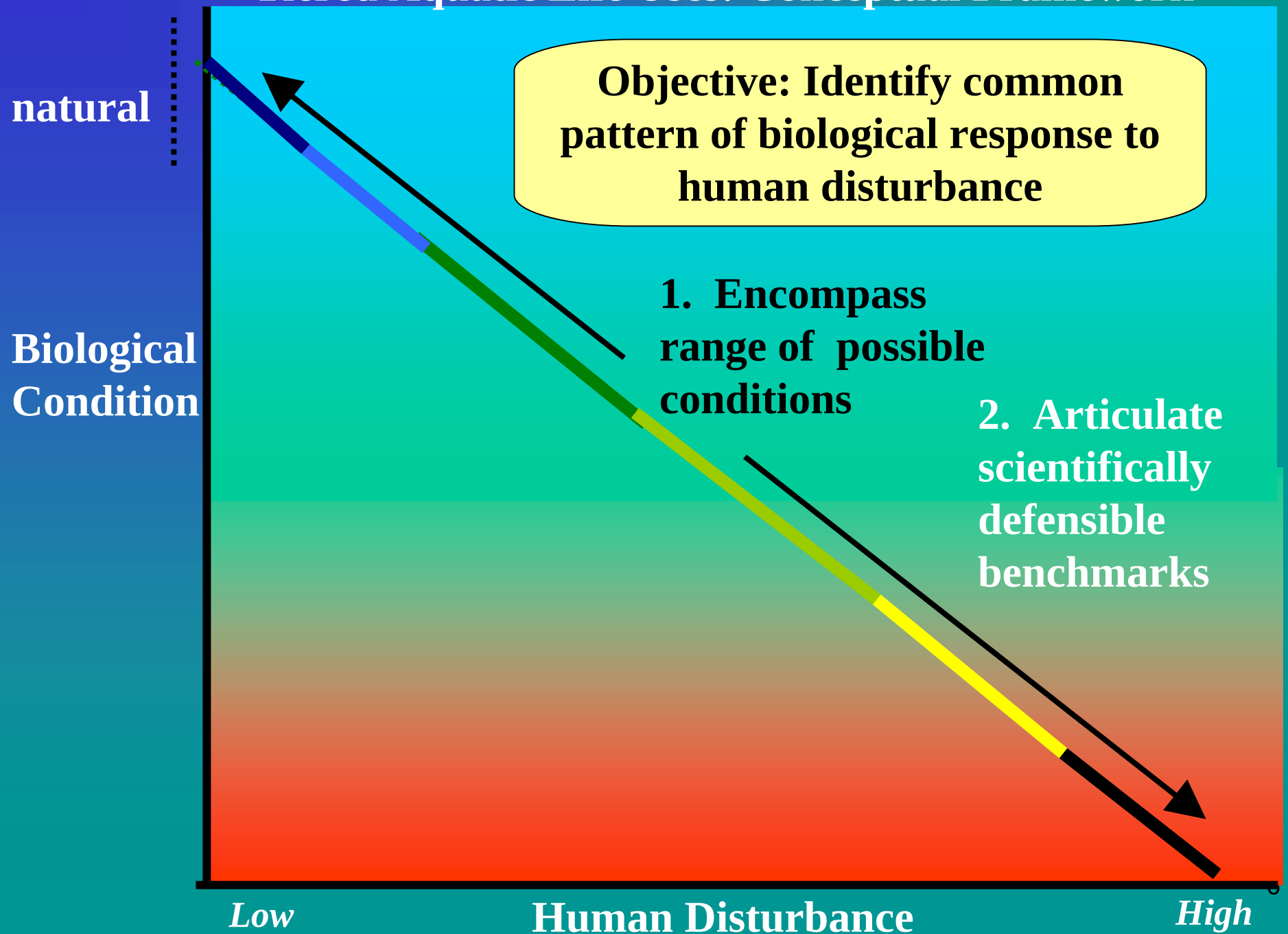


Ridge and Blue Ridge

Societal Response: Clean Water Act

- **Physical, chemical, and biological integrity objective**
- **Fishable/swimmable interim goal (propagation of fish/shellfish/wildlife)**
- **Water Quality Standards Regulation: Designated Uses; Criteria to judge attainment of uses; antidegradation**
- **How do we judge where we are with respect to these mandates? Need some kind of benchmark**

Tiered Aquatic Life Uses: Conceptual Framework



Confusion among Terms

- **Reference condition**
- **Minimally disturbed condition**
- **Historical condition**
- **Least disturbed condition**
- **Reference sites**
- **Minimally disturbed sites**
- **Least disturbed sites**
- **Attainable condition**
- **Others???**

Reference Condition

- **The condition unaffected by anthropogenic disturbance; pristine; unpolluted; natural**

- **Reserve the term as a descriptor for biological integrity**

Minimally Disturbed Condition (MDC)

- **Condition nearly unaffected by anthropogenic disturbance**
- **Could be pristine, natural, undisturbed**
- **Condition essentially stable over time**

Historical Condition

- **Pre-intensive agriculture**
- **Pre-European settlement**
- **Pre-Columbian**
- **Guide for characterizing Reference Condition**

Least Disturbed Condition (LDC)

- **Present day condition found in conjunction with the best available physical, chemical, and biological habitat conditions given present day extent of human activities**

- **Condition found in presence of lowest amount of anthropogenic disturbance**

- **Condition can change over time as land management improves with respect to aquatic condition**

Distinguishing minimally and least disturbed

- **Minimally Disturbed: An absolute. Some regions might have no sites that meet minimal disturbance criteria**
-
- **Least Disturbed: Relative. No matter how disturbed the region, some sites are likely less disturbed than others**

Reference Sites

- **Sites selected according to specific agreed upon criteria as minimally disturbed sites or least disturbed sites**

- **Data obtained from reference sites are used to characterize MDC or LDC**

Best Attainable Condition

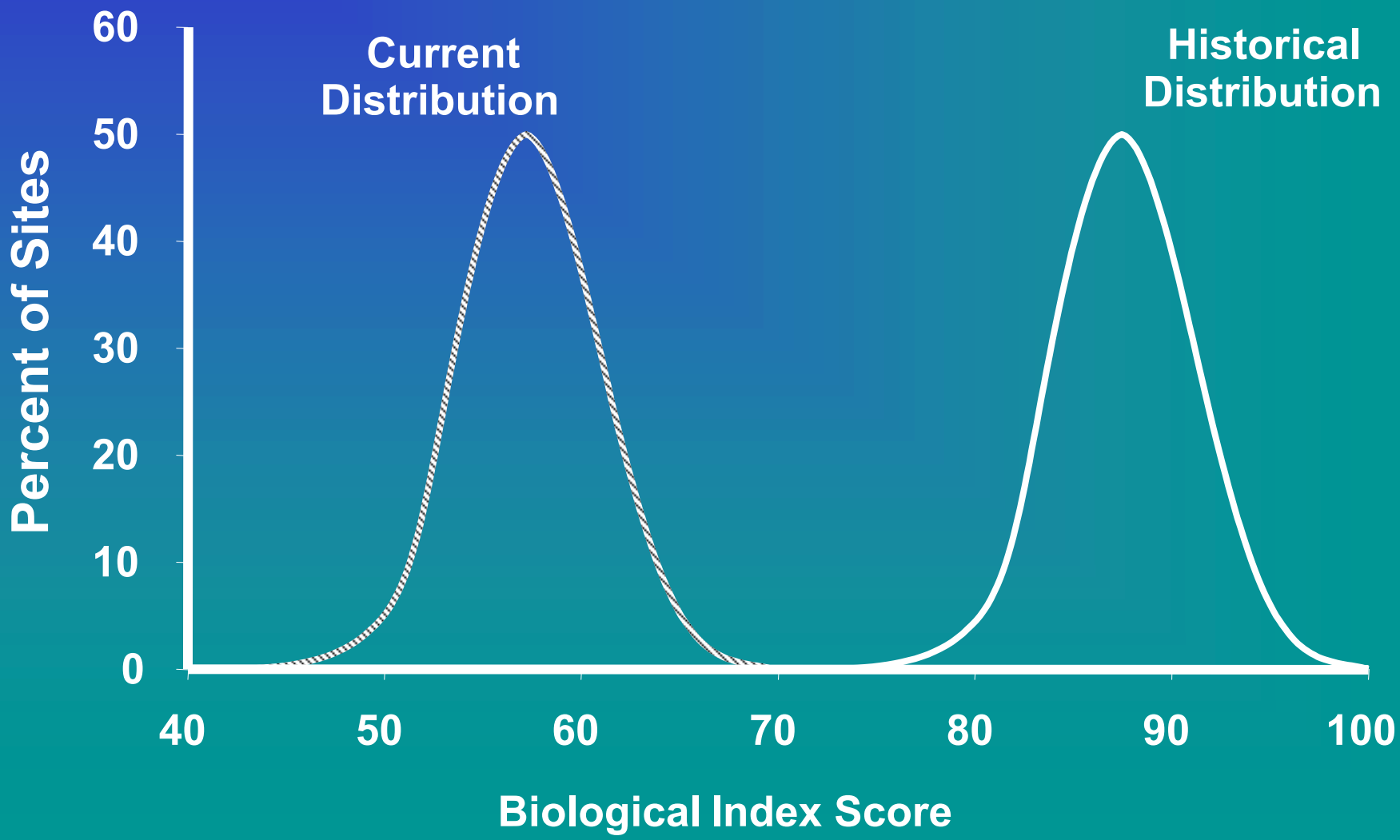
- **An expected condition taking into account best management practices, societal will to improve condition, economic resources**
- **Reduced effect of human activities on aquatic biota (i.e., manage for best condition in face of human disturbance)**
- **Can be better than current day conditions (i.e., better than LDC)**

EMAP-West
Definitions of Reference Condition

- **Minimally Disturbed Condition** - condition of streams in the absence of significant human disturbance (e.g., "natural," "pristine" or "undisturbed")
- Least Disturbed Condition –the best available physical, chemical and biological habitat conditions given today's state of the landscape - defined by a set of explicit criteria to which all reference sites must adhere
- **Best Attainable Condition** – this condition is equivalent to the ecological condition of (hypothetical) least disturbed sites where the best possible management practices are in use

Reference Condition

estimating distribution of sites in reference condition



Reference Condition

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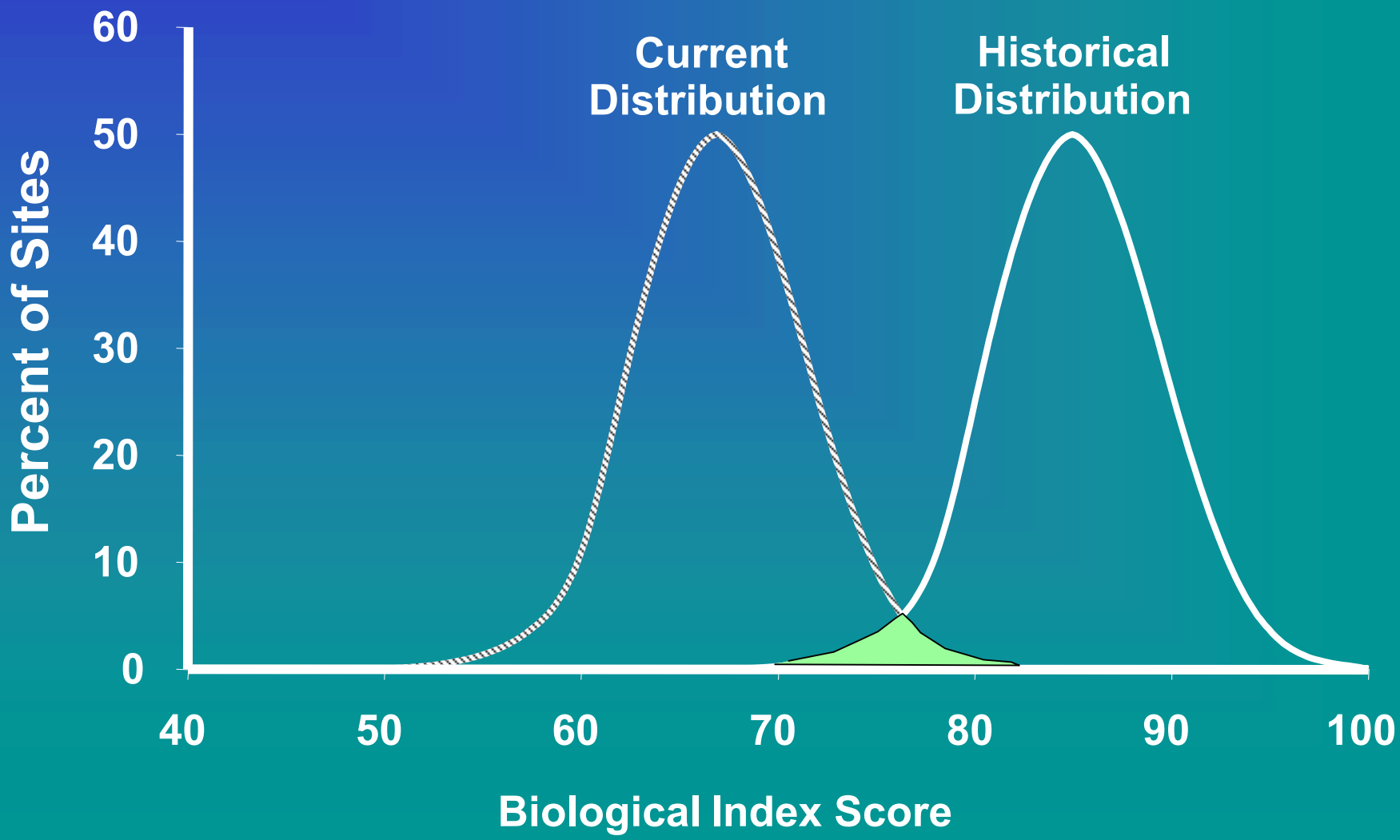

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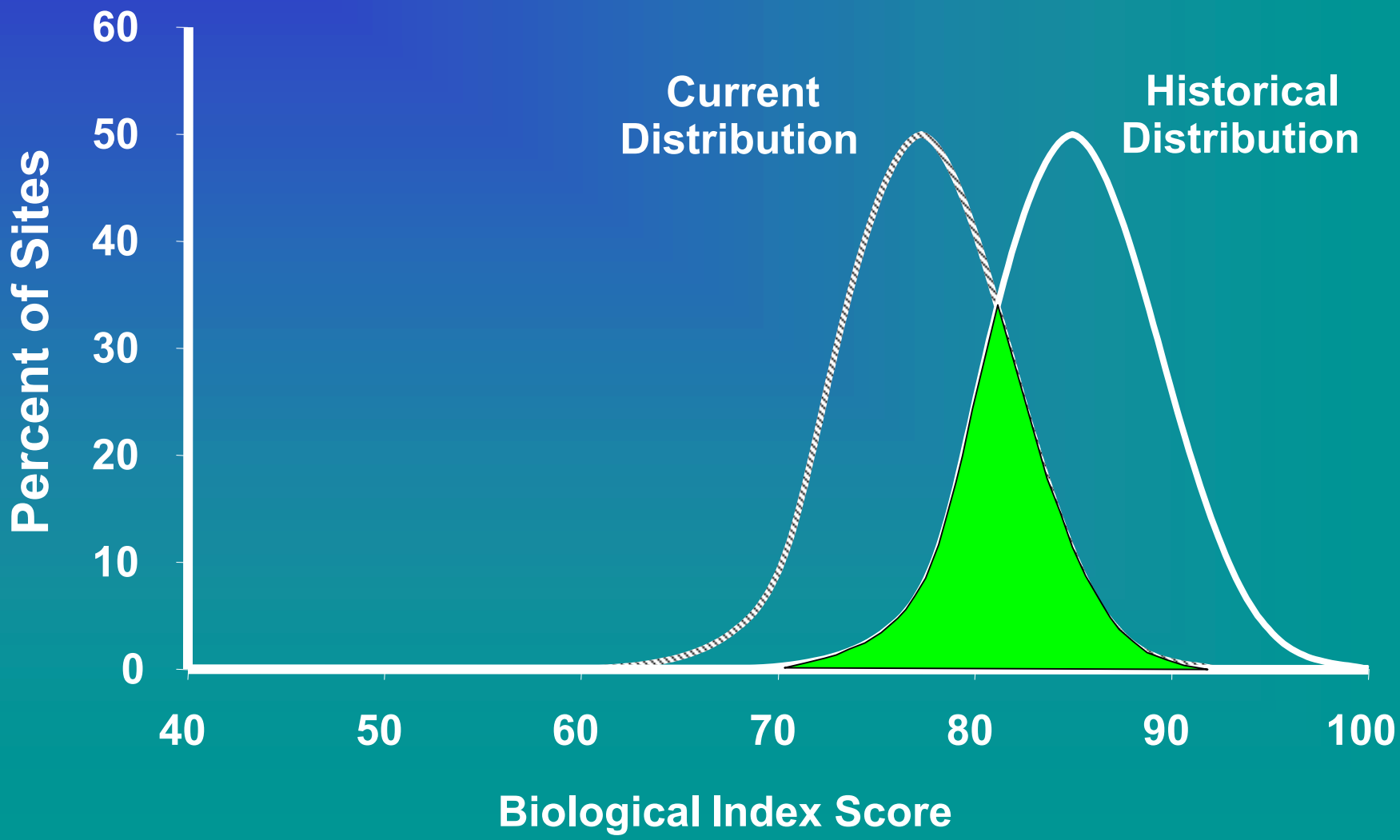
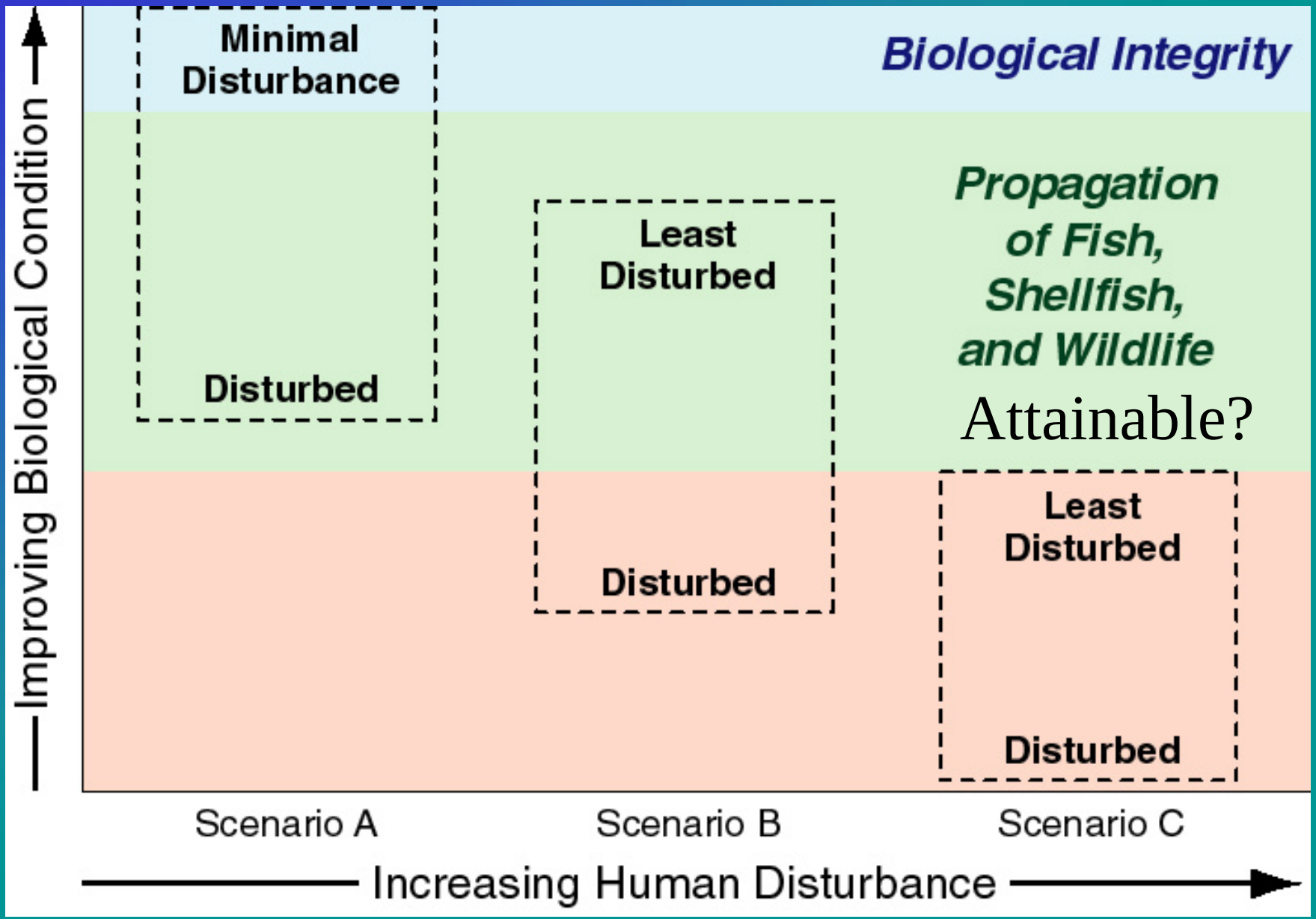



Minimal Disturbance
Disturbed
Biological Integrity
Propagation of Fish, Shellfish, and Wildlife
Attainable?
Least Disturbed
Disturbed
Least Disturbed
Disturbed
Improving Biological Condition
Scenario A
Scenario B
Scenario C
Increasing Human Disturbance

Methods for estimating MDC

- **Condition at minimally disturbed sites**
- **Best professional judgment**
- **Interpreting historical condition**
- **Extrapolating from empirical models**

Methods for estimating LDC

- **Condition at least disturbed sites**
- **Best professional judgment**
- **Ambient distributions**

What do we mean by "Characterizing Condition?"

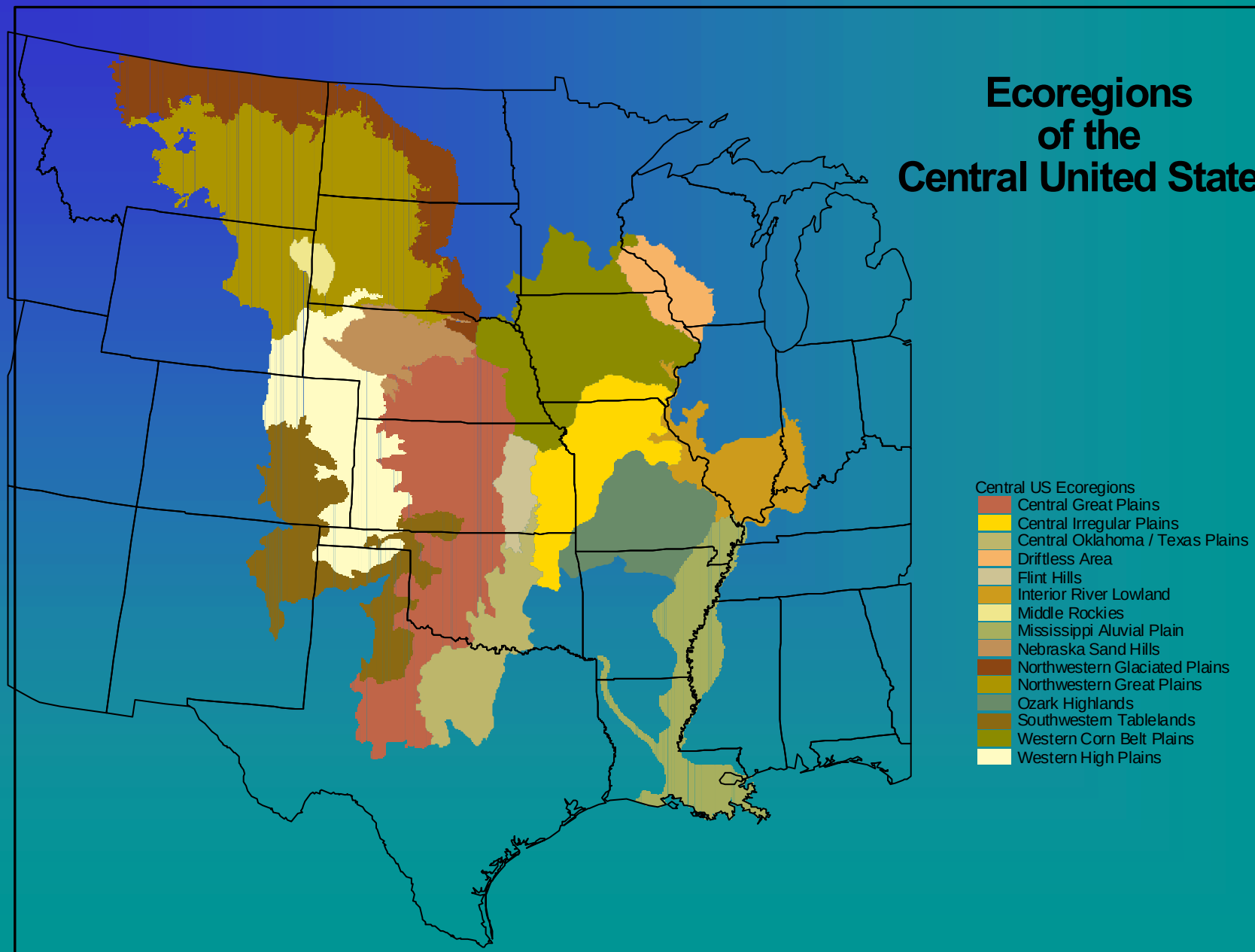
- **Translating concepts to numbers**
  - **Assemblage composition and structure**
  - **Frequency distribution of indicator scores**
  - **Reference condition is not a single number, although we might extract a single number from a distribution as a biological criterion**

Establishing multi-use

Reference Sites for Biological & Nutrient Criteria Development

USEPA Region 7, Central Plains Biocriteria Workgroup and Nutrient RTAG

Ecoregions of the Central United States



SAND HILLS OF NEBRASKA

WESTERN HIGH PLAINS

Reference Site & Condition Definitions

(Gibson, et. al., 1996)

Reference Site **- A specific locality on a waterbody which is minimally (or least) impaired and is representative of the expected ecological integrity of other localities on the same waterbody or nearby waterbodies.**

Reference Condition **- The set of selected measurements or conditions of minimally (or least) impaired waterbodies characteristics of a waterbody type in a region.**

Intended Uses: For a given ecoregion in the Central Plains, "reference conditions" should represent a population of sites that…

- **Accurately characterizes the range of variability present in healthy natural stream systems**
- **Provides an objective definition of the best attainable aquatic conditions**
- **Provides a barometer, ruler, benchmark, or standard against which the condition of other waterbodies can compared**
- **Provides a measurement tool to identify "biological integrity" with respect to the CWA**

Core factors for designation of reference sites

- **Encompass major factors important in defining reference conditions & sites**
- **Incorporate both process (e.g., causal) and outcome (e.g., bio-metrics) factors**
- **Function across all geopolitical, agency and ecoregional boundaries**
- **Serve as *de minimus* (foundational) set of criteria**

Eleven Core Factors *(slide 1 of 2)*

1. **Point sources**
2. **Animal feeding / grazing operations**
3. **Instream habitat**
4. **Riparian habitat**
5. **Land use / land cover (broad scale)**
6. **Land use / land cover (site-specific)**

Eleven Core Factors *(slide 2 of 2)*

7. **Physical and chemical parameters**
8. **Altered hydrologic regime**
9. **Biological metrics**
10. **Biotic assemblages**
11. **Representativeness**

1. Wastewater treatment plants and other point sources

- **Prefer no point source**
- **Acceptable if discharge effects are minimal**
  - **Minimize number, density, and size of facilities**
  - **Site not in close proximity to point source (below effective mixing zone)**
  - **Effluent to stream flow ratio low**
  - **No impairment of aquatic life beneficial use due to point source discharge**
  - **Existing point sources have record of compliance**

Wastewater Treatment Plant Discharge

2. Animal feeding/grazing operations

- **Prefer none**
- **Prefer no cattle access upstream**
- **Acceptable if influence AND potential of degradation is minimal**
  - **Number of facilities low**
  - **Number of animal units low**
  - **Site not in close proximity to cattle access or feeding operations**
  - **Site not in close proximity to land application of livestock waste**
  - **No impairment of aquatic life beneficial use due to livestock impacts**

Mud Creek - Impacted Stream, Iowan Surface Ecoregion (47c). Reduction of riparian vegetation and bank destabilization have resulted in a shallow and wide channel, and development of large sediment bars.

3. Instream habitat

Under reference conditions, instream habitat is characterized by the highest quality and diversity of instream habitat relative to stream type, considering:

- **No excessive sedimentation or embeddedness**
- **No riprap**
- **No unnatural (manufactured) substrates**

Concrete stabilized riprap
Lawrence, KS

4. Riparian habitat

Under reference conditions, riparian habitat would provide an effective buffer which maximizes instream habitat potential:

- **No row crops**
- **No removal of riparian vegetation**
- **Preference to natural riparian conditions**
- **Width, length of riparian area considered**

Middle North Elm Creek Marshall Co., KS

5. Land use and land cover – broad scale (part one)

This consideration involves a two-step process:

- **Step one: Characterize ecoregions or sub-ecoregions using following LU/LC categories:**
  - **Row crop**
  - **Timber**
  - **Grass/herbaceous vegetation**
  - **Artificial (e.g. buildings, impervious cover)**
  - **Water**
  - **Barren (e.g. quarries, mines)**
  - **Land treatment**

5. Land use and land cover – broad scale (part two)

- **Step two: Summarize the LU/LC percentages by 12-digit HUCs (10-40 thousand acres) to develop summary statistics for the range of each LU/LC category.**

6. Land use and land cover – site-specific

For a candidate reference site and its watershed, determine the LU/LC percentages.

Site-specific LU/LC should not be anomalous compared to the broad-scale LU/LC.

Percent of land cover that is natural and/or land use that is treated (e.g., application of BMPs and appropriate land management) exceeds that of broad-scale ecoregion.

7. Physical and chemical parameters

- **Prefer sites meet or exceed aquatic life standards over the long term**
- **Sites should reflect best attainable physical or chemical conditions within ecoregion and flow conditions**

8. Altered hydrologic regime

- **Minimal channelization effects (no influence is preferred)**
- **Prefer sites not under influence of dams**
- **Sites located away from bridges and crossings influences**
- **Sites located away from outfall structures (e.g. storm sewers, tiles) influences**
- **No influence from anthropogenic dewatering**
- **Little or no influence of impervious surfaces or urban runoff**

Straighten and lined stream channel

9. Biological metrics

- **This is not a stand-alone factor**
- **Index of metric scores should be among the highest for a defined population in region**

✓ ***Caveat*: This is data-driven to determine if site will be a valid reference site**

✓ ***Caveat*: Not a good choice to select your site, but a good check on the validity of the site being considered for reference level**

10. Biotic assemblages

- **Biotic diversity is consistent with both historical assemblages (where available) and current distributions**
  - **Presence of rare/unique communities**
  - **Limited number of exotics**
  - **Temporal variations considered**
  - **Few native species lost**
  - **Presence of threatened or endangered species**
- **Consider influence of stream classification and size**
- **Consider factors that influence migration (e.g., dams, reservoirs, drainage divides)**

Snake River Nebraska

11. Representativeness

- **Reference sites should represent the range of biological, physical, and chemical conditions of the ecoregion**
- **These sites should be minimally disturbed by anthropogenic activities**
- **A sufficient number of sites should be selected to adequately represent different stream classes (e. g. cold water, saline, large, small) and capture the natural variability within specific classes**

Using reference sites/systems to define biological and nutrient criteria values

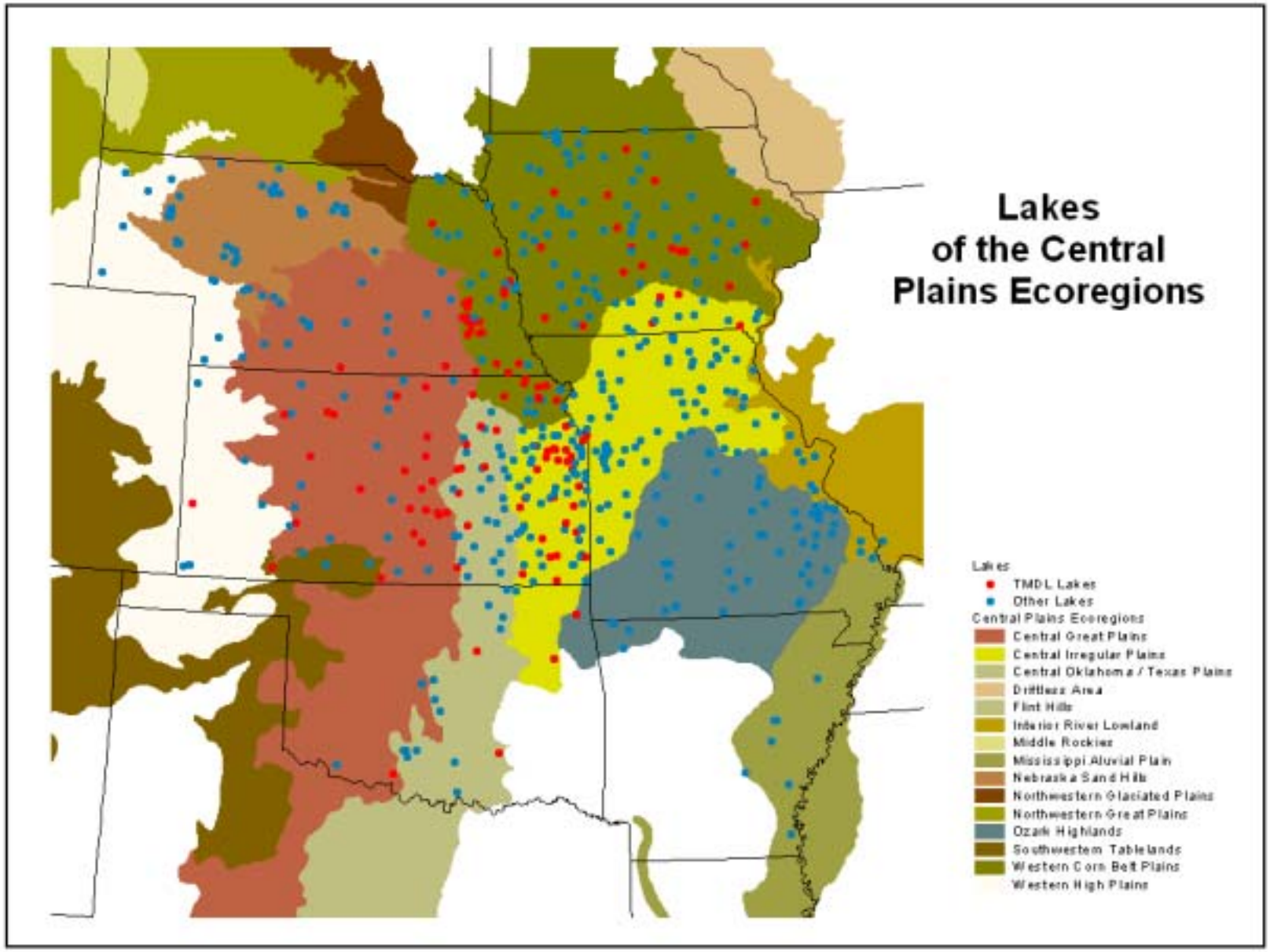
- **Broadly defined and quantified reference conditions should identify high quality sites or systems that possess minimally altered physical, chemical and biological states**
- **Reference sites or systems exhibiting high quality biological systems should be indicative of acceptable and above average water and habitat quality**

Total Phosphorus, Total Nitrogen and Chlorophyll a records for Central Plains lakes

- **Over 500 lakes and reservoirs over 10 acres in size in the database**
- **Over 30,000 individual records for TP, TN, Chlorophyll a, Turbidity, Secchi depths**
- **Approximately 120 reference lakes identified by BPJ of regional experts**
- **Tri-section method applied using chlorophyll a values as biological indicator to select potential reference lakes**

Comparisons of TP, TN and Chl a for all lakes vs. reference lakes

ALL LAKES	BPJ	TRI-SECTION
TN = 1125	TN = 1165	TN = 602
TP = 78.8	TP = 51.0	TP = 35.5
Chl a = 17.1	Chl a = 10.9	Chl a = 6.7


Lakes
of the Central
Plains Ecoregions
Lakes
TMDL Lakes
Other Lakes
Central Plains Ecoregions
Central Great Plains
Central Irregular Plains
Central Oklahoma / Texas Plains
Driftless Area
Flint Hills
Interior River Lowland
Middle Rockies
Mississippi Alluvial Plain
Nebraska Sand Hills
Northwestern Glaciated Plains
Northwestern Great Plains
Ozark Highlands
Southwestern Tablelands
Western Corn Belt Plains
Western High Plains

Comparisons of TP, TN and Chl a for all lakes except Sand Hills lakes

ALL LAKES	BPJ	TRI-SECTION
TN = 1122	TN = 755	TN = 610
TP = 70.0	TP = 31.5	TP = 35.0
Chl a = 16.5	Chl a = 7.4	Chl a = 6.8

Total Phosphorus, Total Nitrogen and Chlorophyll a Records for Regional Streams

- **787 streams sampled**
- **Number of Reference Streams (BPJ) = 167**
- **Number of Non-reference Streams = 554**
- **24,195 individual records**
  - **TP + Chlorophyll a records = 102**
  - **TN + Chlorophyll a records = 5**
  - **TP + TN + Chlorophyll a = 1142**

Non-reference vs. Reference BPJ (all regional streams)

- **Chl a = 8.7**
- **TP = 180**
- **TN = 1890**

- **Chl a = 4.5**
- **TP = 90**
- **TN = 1480**

Non-reference vs. Tri-section by IBI (REMAP streams)

- **IBI = 67.5**
- **TP = 210 ug/L**
- **TN= 1900 ug/L**

- **IBI = 74.1**
- **TP = 167 ug/L**
- **TN = 1510 ug/L**

REMAP Streams
Tri-section Reference Streams

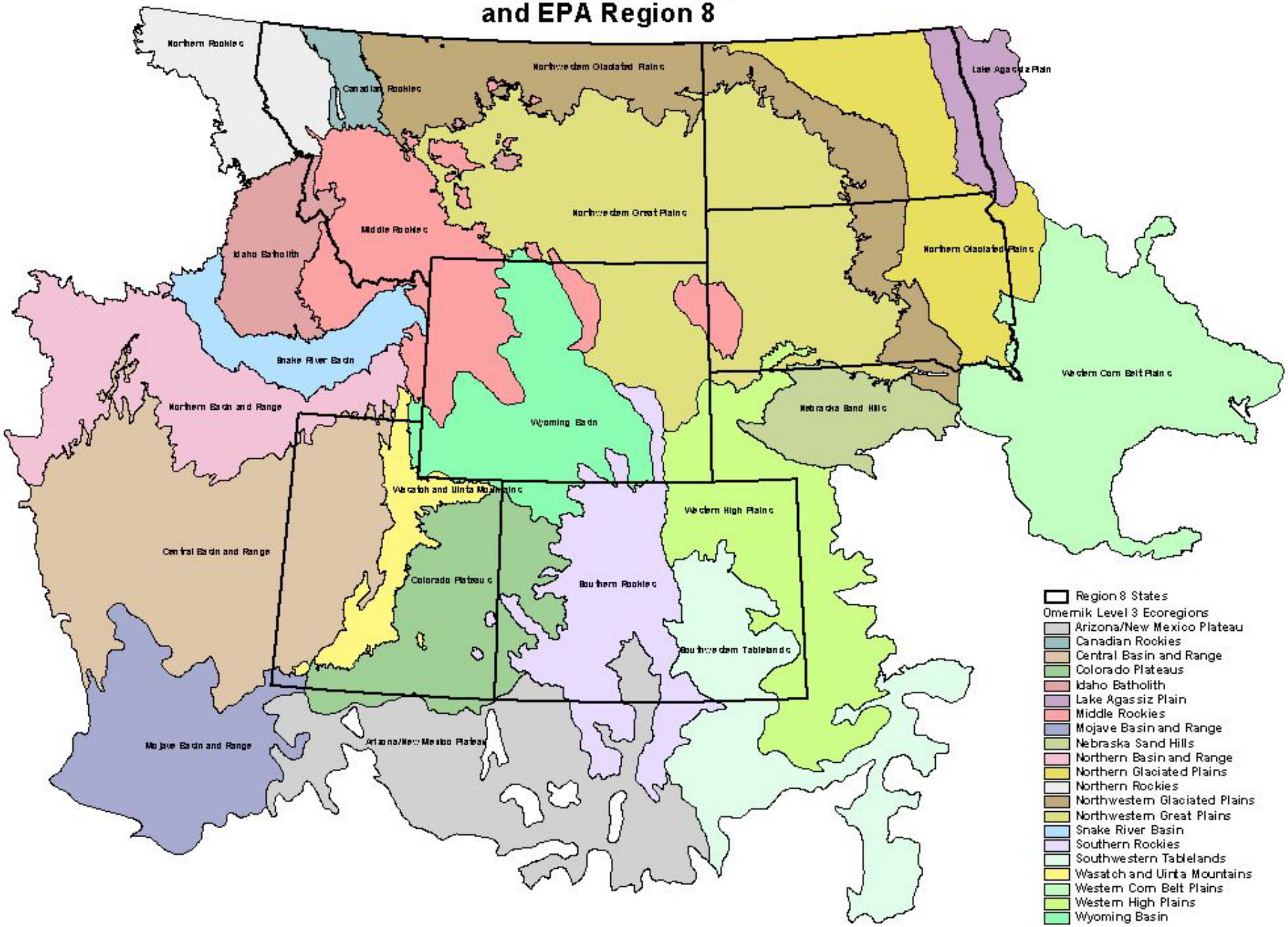
ALL STREAMS	Selected By IBI	Selected by TP	Selected by TN
IBI = 67.5	IBI = 74.1	IBI = 63.8	IBI = 64.0
TP = 210	TP = 167	TP = 80	TP = 157
TN = 1900	TN = 1510	TN = 1370	TN = 880

Selecting Reference Sites

- **Accounting for Natural Variation**
- **Techniques for Reference Site Selection**
- **EMAP-West Techniques**
  - **Probability Site Evaluation**
  - **Screening / Evaluating Candidate Sites**

Various Streams

Omernik's Level 3 Ecoregions and EPA Region 8



Techniques for Selecting Reference Sites

- **Least and Most Disturbed from a Random Survey**
- **Best Professional Judgment (BPJ)**
- **Screening Process**
- **Data Filtering**

Selection from a Random Survey

- **Highest ‘x’ percent along condition gradient from a Random Survey**
- **Lowest ‘y’ percent along condition gradient from a Random Survey**

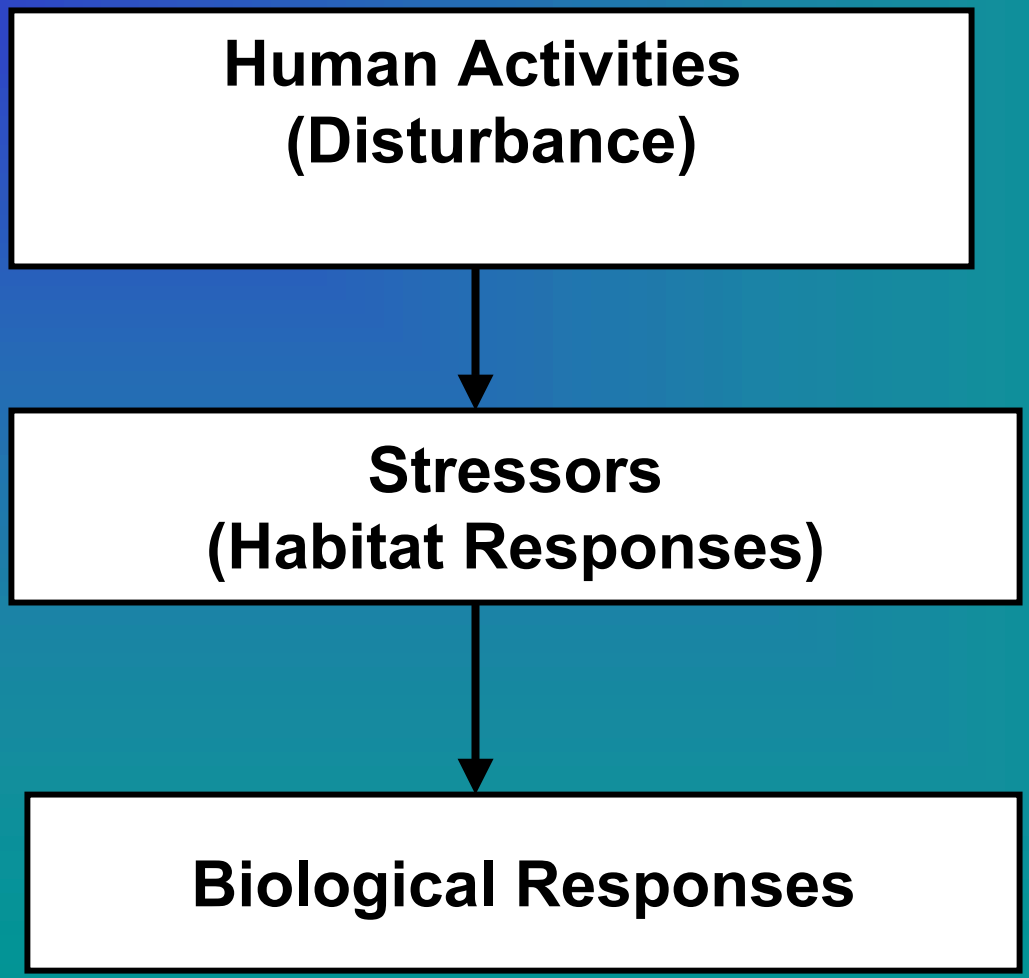
Best Professional Judgment

- **Requires Local Knowledge**
- **Most processes end up with BPJ in the final steps**
- **Issues with only using 'Handpicked' Sites**
  - **Differences Among Professionals**
    - **20 professionals = > 15 or 30 different opinions**
  - **Results could be another version of describing the variation in condition**

Screening Process for Reference Site Selection

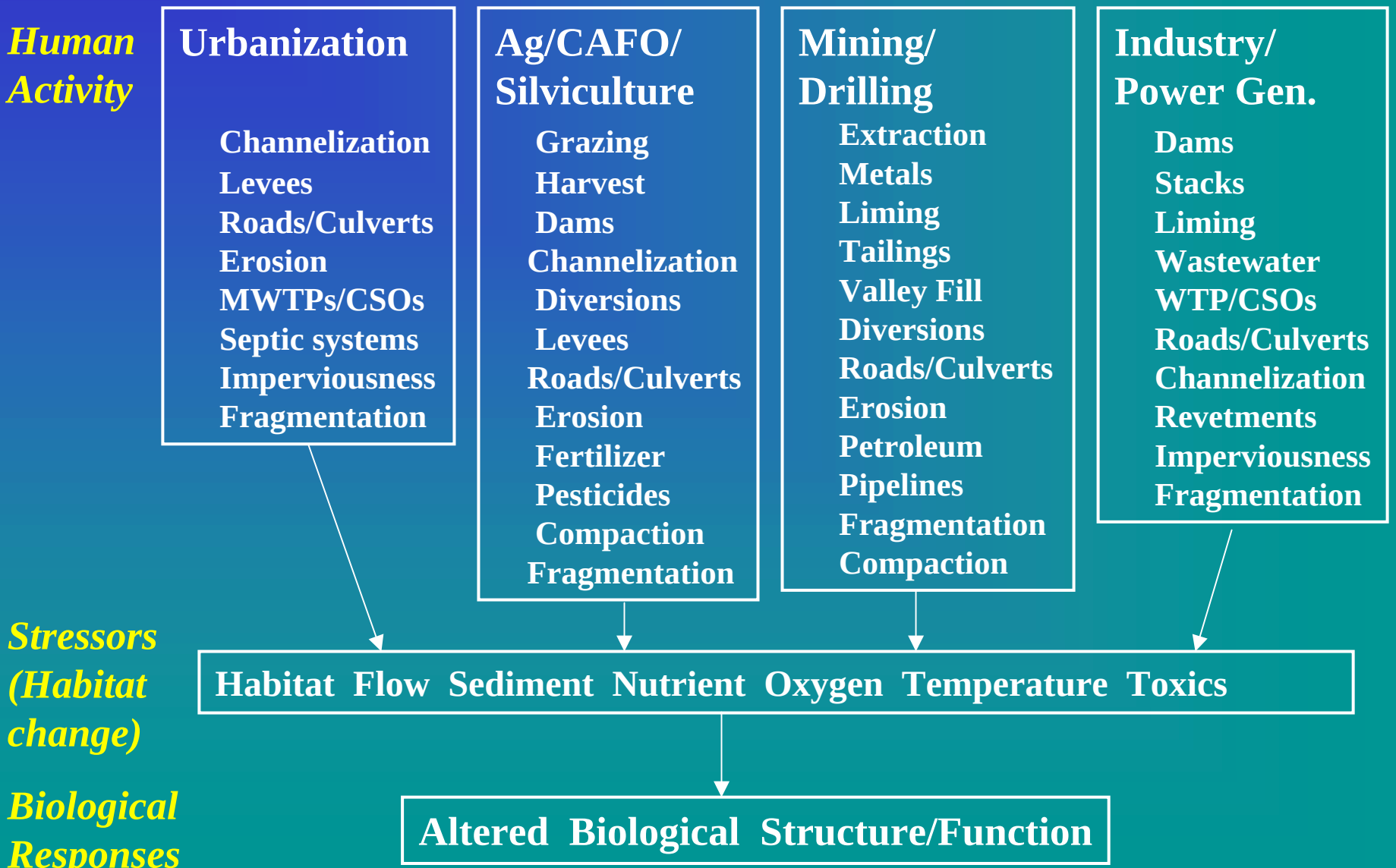
- **An iterative screening process for selecting sites**
  - **That are minimally or least disturbed by human activities and resultant stressors**
  - **That are representative of the aquatic resource in the region of interest**
- **Guided by indicators of human disturbance/stress**
  - **In the atmosphere**
  - **In the landscape/watershed**
  - **In the riparian corridor or near the site**
  - **In the channel**
  - **In the water**
  - **In the biota**
- **Available at different spatial scales**

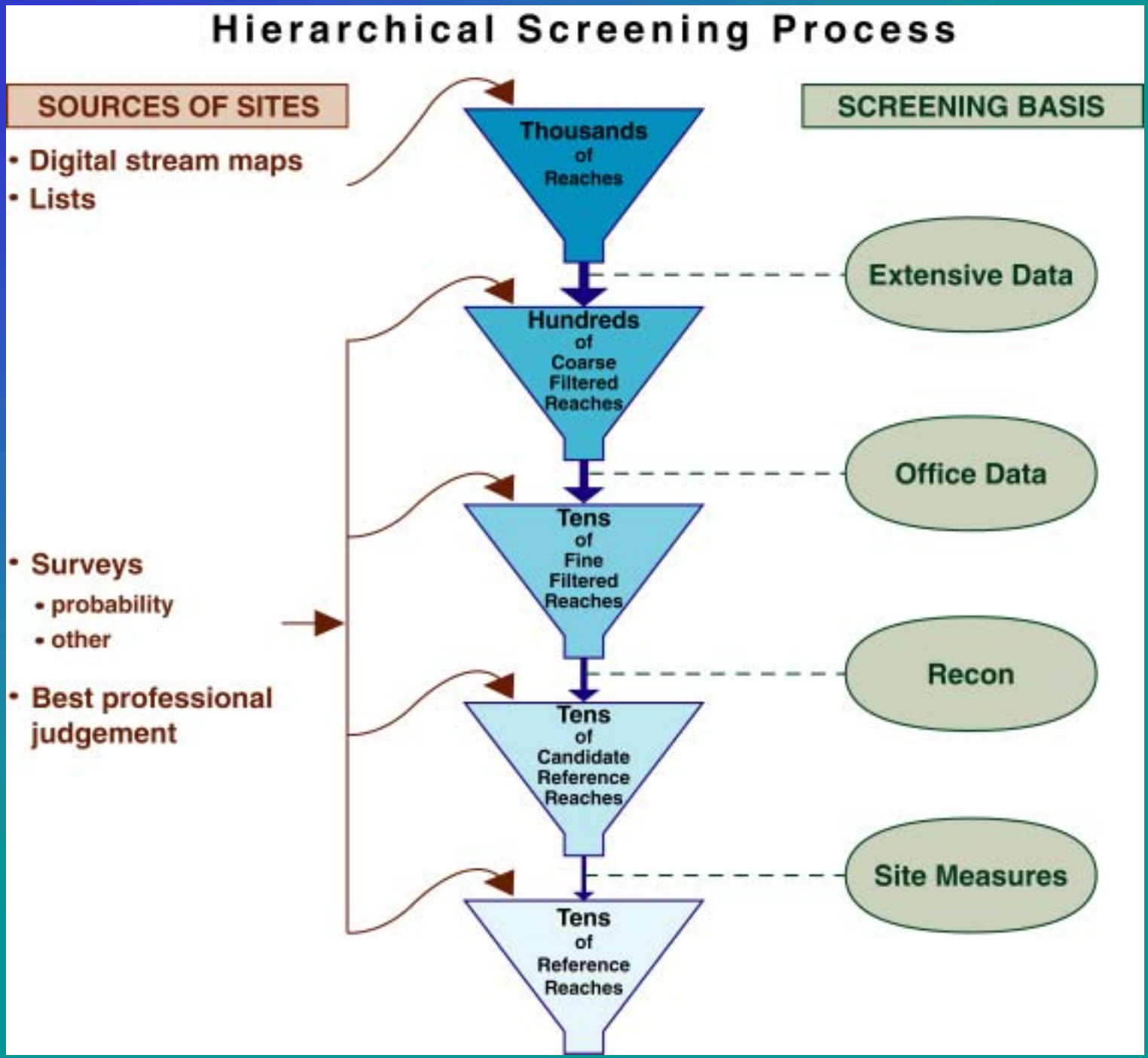
A simple conceptual model: Human activity > stressors > responses



A more complex conceptual model

(from Bryce et al. 1999. J. Am. Wat. Resour. Assoc. 35:23-36)




Hierarchical Screening Process
SOURCES OF SITES
• Digital stream maps
• Lists
• Surveys
• probability
• other
• Best professional judgement
SCREENING BASIS
Thousands of Reaches
Extensive Data
Hundreds of Coarse Filtered Reaches
Office Data
Tens of Fine Filtered Reaches
Recon
Tens of Candidate Reference Reaches
Site Measures
Tens of Reference Reaches

EMAP-West Reference Site Selection

BPJ Reference Site:
WMTP99-R004
Ecoregion: Northwestern Great Plains
Total Phosphorus = 160 µg/L
LRBS = -2.6

Probability Site:
WSDP99-0604
Ecoregion: Northwestern Great Plains
Total Phosphorus = 7 µg/L
LRBS = 0.9

Processes for EMAP-West Reference Site Selection (a mixture)

- **Evaluation of Probability Sites**
  - **Data Filtering**
- **Screening Process for all reaches**
  - **Utah and Northwestern Great Plains**
- **BPJ for Candidate Sites**
- **Screening Process applied to Candidate Reference Sites**
  - **Chuck Hawkins Reference Sites**
  - **State BPJ Sites**
  - **Probability Sites**

Evaluation of Probability Sites 'Data Filtering'

- **Evaluation Uses sampled chemistry and physical habitat data to 'filter' out disturbed sites**
  - **At this stage, 'filters' are fairly crude (nutrients, sediments) and will need refinement for ecoregions of the West**
  - **Gives us a check on state BPJ sties**

Evaluation of Probability Sites Objectives

Describe a Process to:

- **Select sites representing the "Least" and "Most" disturbed conditions across the full ranges of natural gradients**
- **Integrate multiple disturbance indicators**
- **Using regional-scale survey data**

Thom Whittier, et.al., Dynamac Corp., Corvallis

Methods

- **Use distributions of disturbance indicator scores to guide criteria for 'least' & 'most' disturbed conditions**
- **Examine correlations among natural gradients & disturbance gradients**
- **For each disturbance indicator**
  - **Plot against most correlated natural gradient**
  - **Draw line to capture ~10-20% of least and most disturbed sites along length of gradient**
  - **Assign 1 or 0 for 'Least Disturbed' category**
  - **Assign 1 or 0 for 'Most Disturbed' category**
- **For each site, sum number of 'hits' for 'Least Disturbed' or 'Most Disturbed'**
  - **Select sites with highest scores in each category**

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Conclusion: It's a Useful Tool

- **Being used to classify condition of sites across EMAP-West from probability sites**

- **Least and Most disturbed sites to be used to evaluate metric selection or O/E models (predictive models)**
  - **Fish**
  - **Macroinvertebrates**
  - **Periphyton**

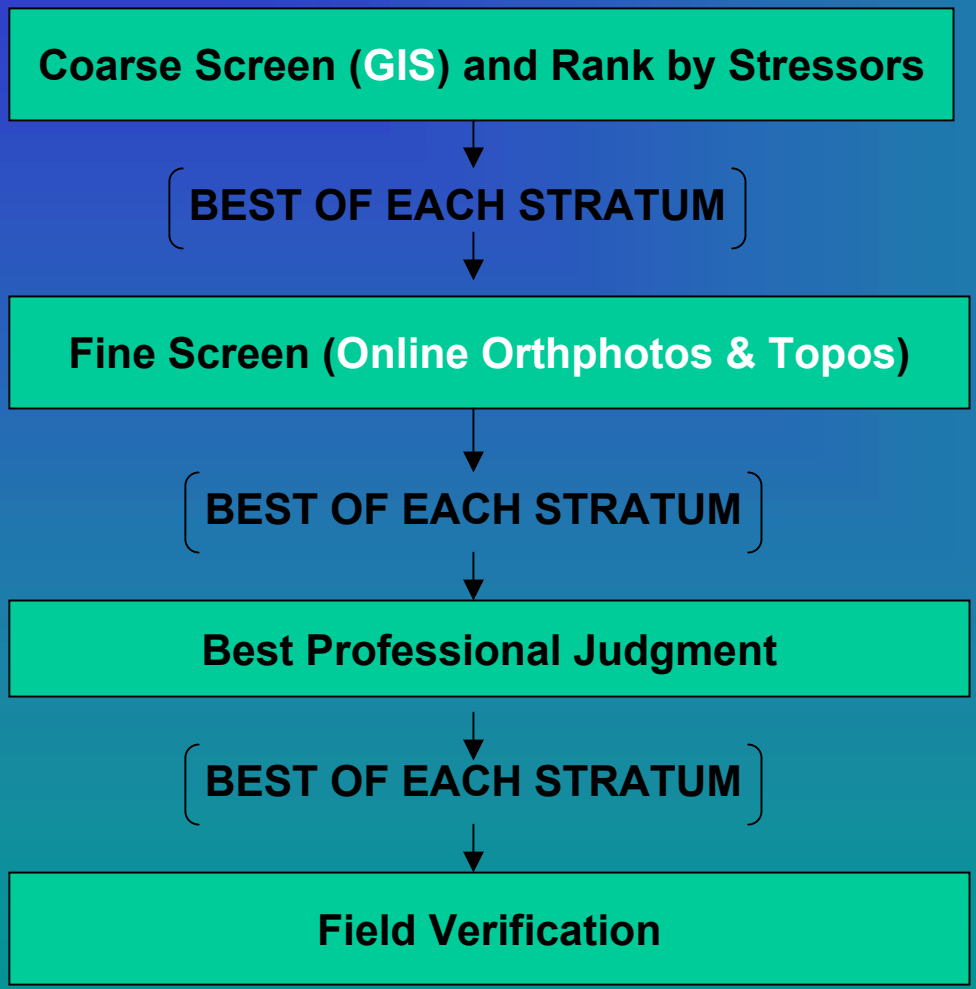
Thom Whittier, et.al., Dynamac Corp., Corvallis

A Screening Process for Selecting Least Disturbed Sites

Piloted in Utah and Refined in the Northwestern Great Plains Ecoregion

Developed by Peter Lattin, Dynamac Corp.

Conceptual Approach



(REACHES)

Hundreds of thousands

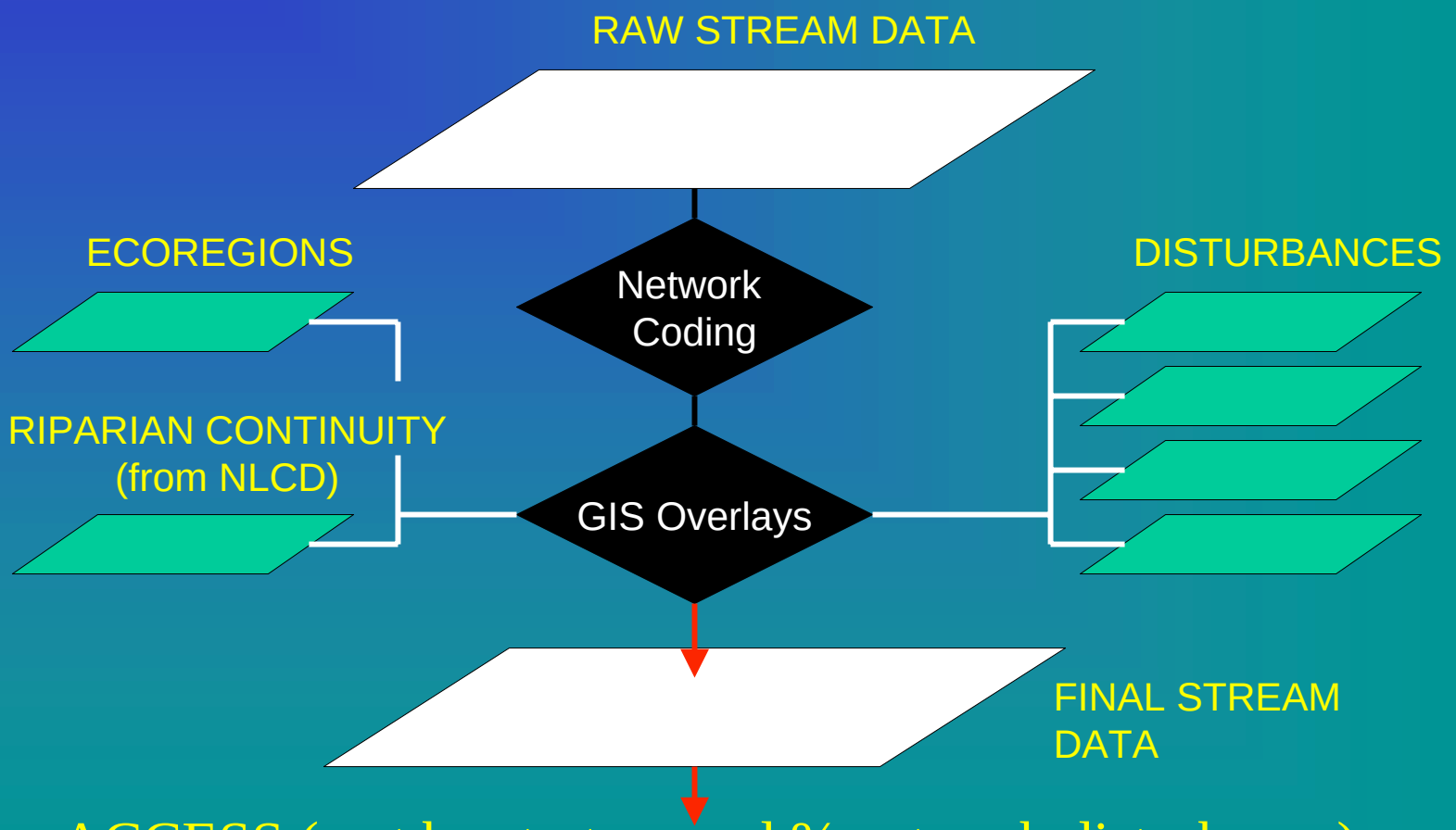
Hundreds

Tens to hundreds

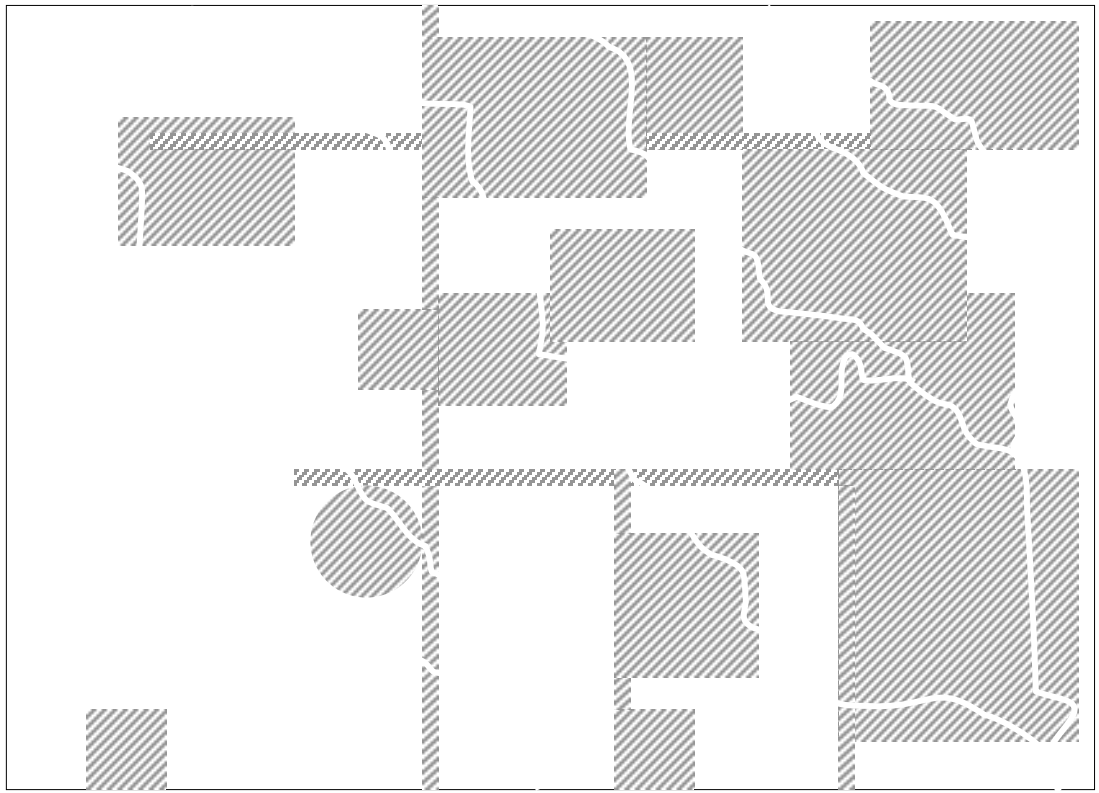
Tens

Peter Lattin, Dynamac Corp., Corvallis

Overview of Coarse Screening Process



Buffered Disturbances with Stream Networks



Disturbed

Undisturbed

Streams

(Calculation)

% Network Disturbance =

$$\frac{\text{Length(disturbed)}}{\text{Length (total)}}$$

The Final Inventory – All Networks

Each Reach is:

- **Coded by flow status**
- **Coded as inside or outside of a stressor buffer zone**
- **Stratified by:**
  - ✓ **Biophysical strata (example: stream order x ecoregion)**
  - ✓ **Ranked by ascending percent disturbance**
- **Ancillary data provided for building database queries:**
  - ✓ **Presence of impoundments in the network**
  - ✓ **Presence of mines close to the network**
  - ✓ **Approximate livestock density at the HUC level**
  - ✓ **Riparian continuity**

Fine Screening

- **Operational Definition: Evaluation of a set of the *least disturbed* Coarse Screened reaches using available online digital orthophotos and topographic maps, to create a ranked list by estimated level of stressors in the network, stratified by ecoregion and stream order.**

- **Two levels:**
  - **Rapid**
  - **Detailed**

Rapid Screen Disturbance Scoring

- **Rapidly identify best sites (least disturbed reaches in least disturbed catchments)**
- **Use on-line digital orthophotos and topo maps**
- **Single score (0 – 10) reflecting disturbance severity/extent (0 = least)**
- **List major disturbance types**
- **Less than ½ hr. per reach / catchment**

Detailed Fine Screening

- **Identify candidate least disturbed sites for BPJ screening**
- **Scores each disturbance type separately for reach and catchment**
- **Non-linear scale (0 – 40) to distinguish sites with multiple low-level disturbance from single high-level disturbance**
- **Ranking based on total score**
- **Goal: 3-4 candidates per stratum**

Example Scoring Criteria

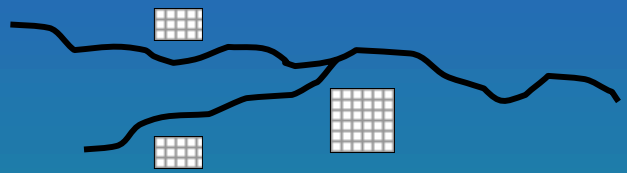
NOT DETECTED (0)	= not detected in imagery	
LOW	(1)	= present, impact unlikely due to distance or riparian buffer; or light and localized impact
	(5)	= low impact probable
MODERATE	(10)	= low impact obvious for most of stream; or high but concentrated impact
HIGH	(20)	= moderate impact for most of stream; or very high but concentrated impact
SEVERE	(40)	= high impact for most of stream; or severe concentrated impact

What Might This Look Like?

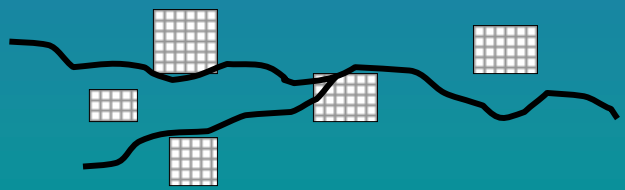
SEVERITY SCORE

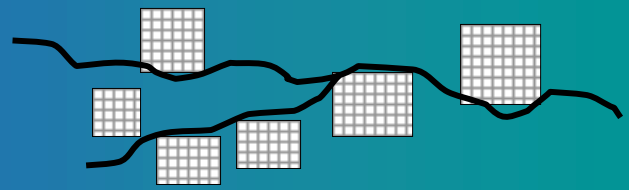
(1)

(5)



(10)





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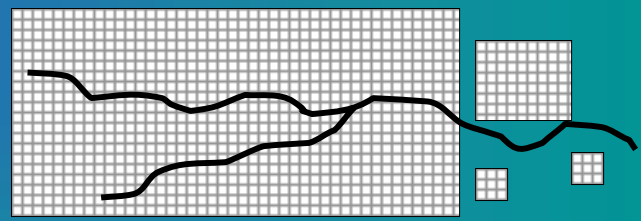
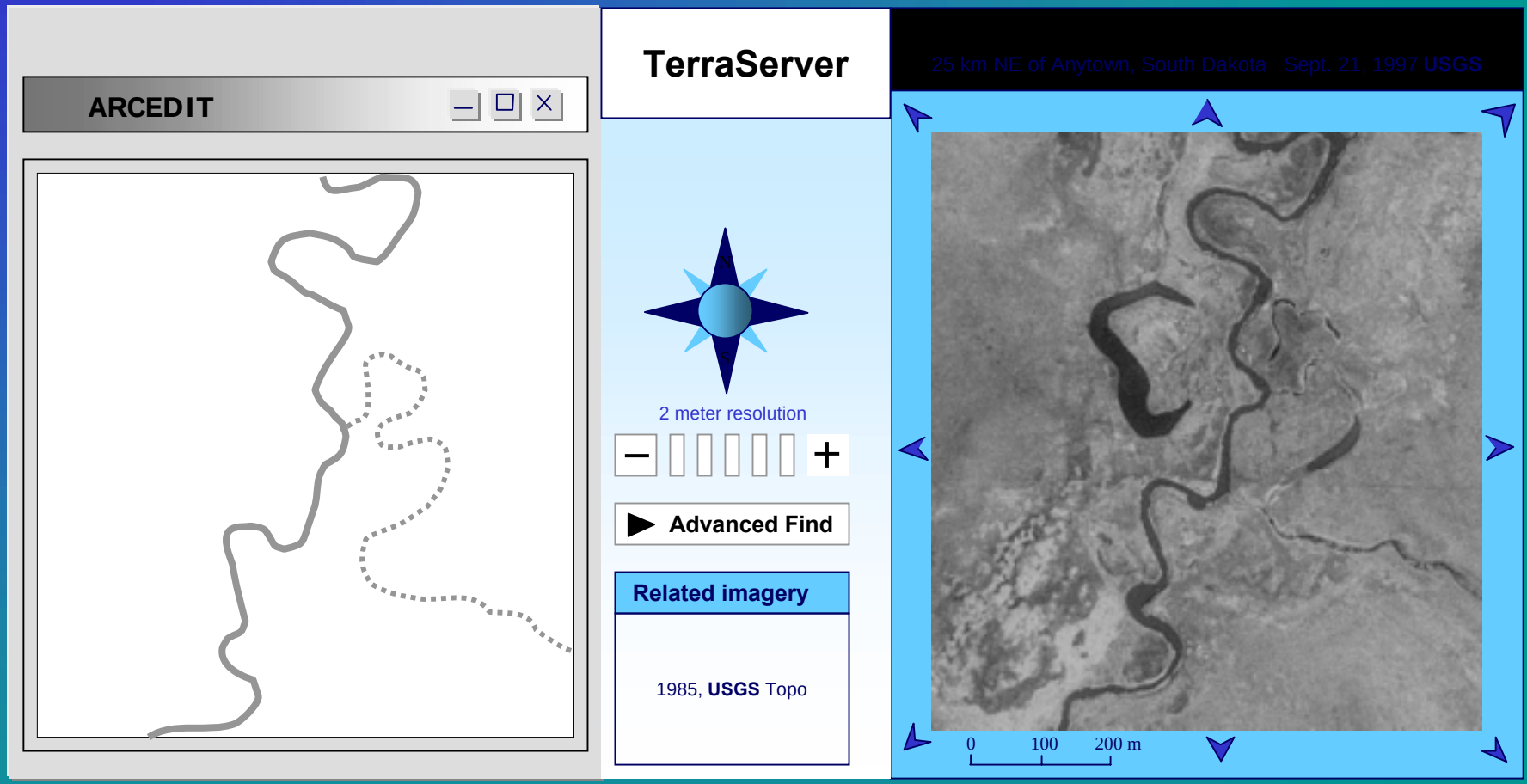
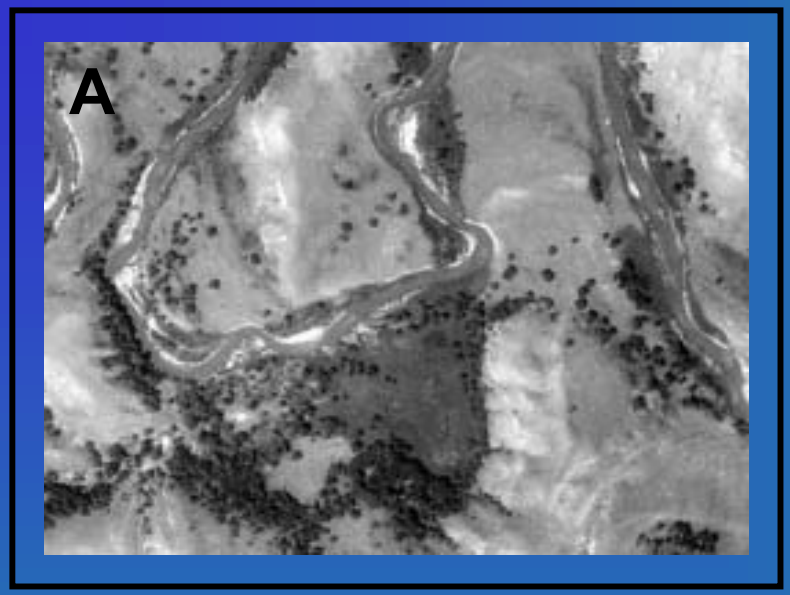


(40)

Simplified Split-Screen Work Environment





Rapid Visual Screen to Identify the Least Disturbed Reach in the Network

Fine Screen Output

- **~ 3 – 4 candidates from each stratum (e.g., stream order x ecoregion)**
- **Mapped locations of reaches**
- **List of local contacts for BPJ review of sites**

The BPJ Process

- **Local contacts established**
- **Contacts are provided with**
  - ✓ **Maps & site information (approximate catchment boundaries, reach)**
  - ✓ **Scoring instructions**
  - ✓ **Standardized scoring sheets**
- **The best BPJ sites (perennial and 'least disturbed') from each stratum are identified for field inspection**

Field Reconnaissance

- **Sites with the lowest scores from each stratum are field inspected via:**

  - ✓ **Aerial reconnaissance of the watershed**

  - ✓ **Ground truthing of the reach**

The Final Fine Screen Product

- **Recommended list of candidate reaches for future field sampling**

Disturbance in Perspective in the Northwestern Great Plains

Above: Although this site is surrounded by grasslands and very little development, it is heavily impacted from grazing. The site is one of the 'impaired' sites for the Montana Northern Plains REMAP study.

Below: Although this site is entering a town with development on both sides, the stream is protected from grazing. The site is one of the Montana Northern Plains REMAP reference sites.

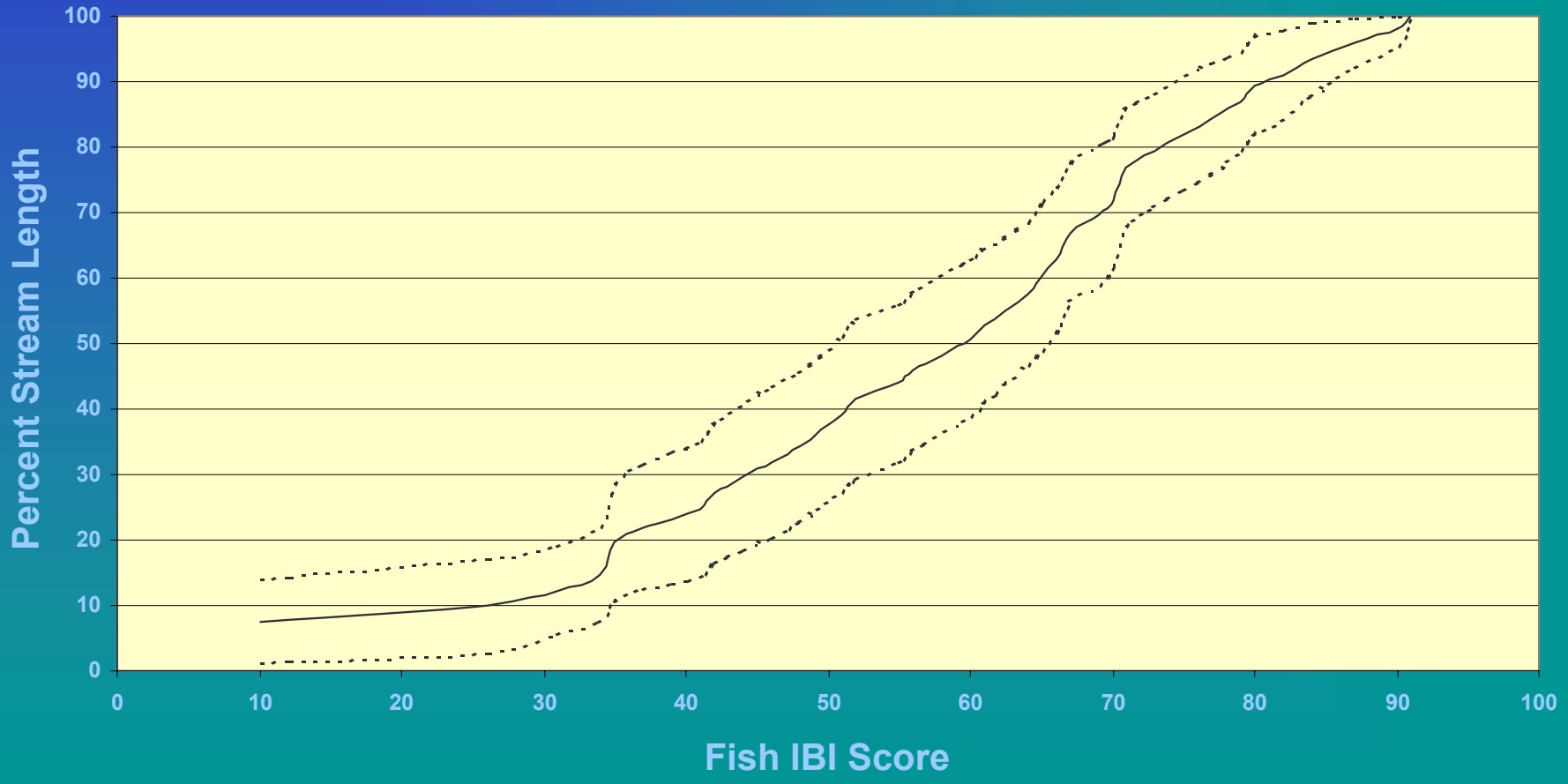
Screening Process applied to existing Candidate Reference Sites

- **Portions of Peter Lattin's Screening Process Implemented for all of the EMAP-West Study – the Western United States (Regions 8, 9, and 10)**
  - **Only Site Locations Screened and no need for BPJ and Recon Steps**
- **Screening Performed for Specific Candidate Sites**
  - **Chuck Hawkins BPJ sites (1000+)**
  - **State BPJ Sites**
  - **Candidate EMAP-West Probability Sites**

Threshold Setting Objective for Ecological Stream Condition

- **To categorize the ecological indicators into 'Good', 'Moderate/Fair', and 'Poor' Classes**
  - **Requires a determination of the condition of streams based on fish IBI, macroinvertebrate IBI, other biological measures, chemistry, physical habitat, and landscape indicators**
  - **Requires a determination of condition for the same indicators for least disturbed sites**

MT-NGP Fish IBI Cumulative Distribution Function



Montana Northern Plains REMAP Study – Tom Johnson, EPA Region 8

Determining Thresholds

- **Define Reference Sites, Use <25th Percentile as "Fair" and <5th or <1st Percentile as "Poor"– Requires large number of Reference Sites (EMAP method)**

- **Define Reference Sites – Use <25th Percentile as line between Fair and Good and Divide Range into three equal parts below (very poor / poor / fair) and two equal parts above (good / very good)**

Determination of "Reference" Sites

- PCA on all sites using chemistry and physical habitat
- Plotted first 2 axes. Chose the 25 best sites from that plot
- Screened those 25 for the following parameters (needed to meet all):

DO >= 5.0 mg/l	Embeddedness <= 85%
SO4 <= 800 mg/l	Percent Fines <= 50%
TP <= 0.100 mg/l	Human Influence Index >= 614
TN <= 0.88 mg/l	Human Land Cover 5km <= 25%

- Screened those 25 for the following parameters (needed to meet all):
- 6 Sites survived this process, 4 in the NW Great Plains, 2 in the NW Glaciated Plains.
- Best in the dataset, not necessarily the very best of what is out there

Determination of "Impaired" Sites

- PCA on all sites using chemistry and physical habitat
- Plotted first 2 axes. Chose the 19 worst sites from that plot
- Screened those 19 for the following parameters:

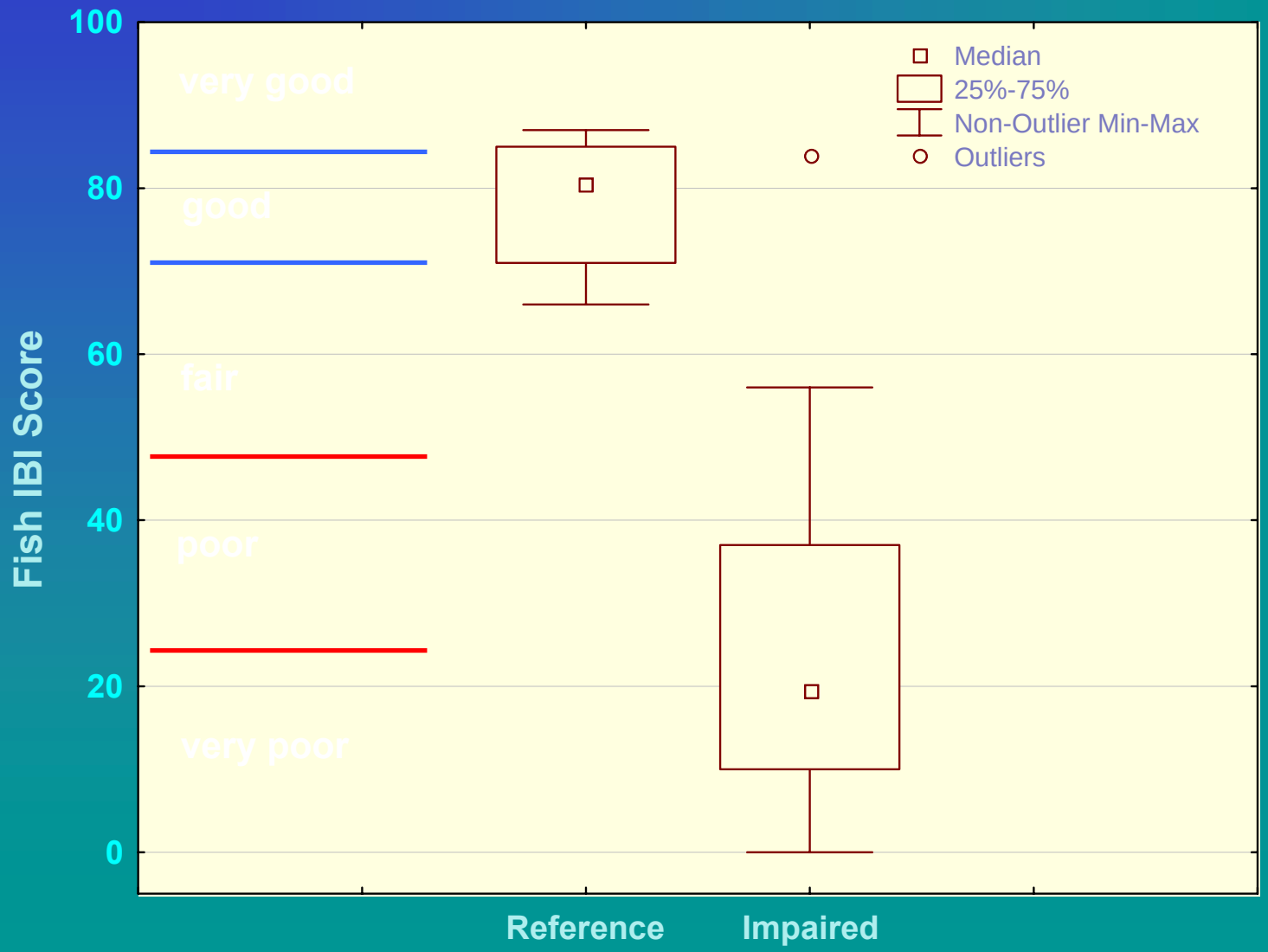
DO < 5.0 mg/l
SO4 > 1500 mg/l
TP > 0.300 mg/l
TN > 0.88 mg/l

Embeddedness > 95%
Percent Fines > 85%
Human Influence Index < 505

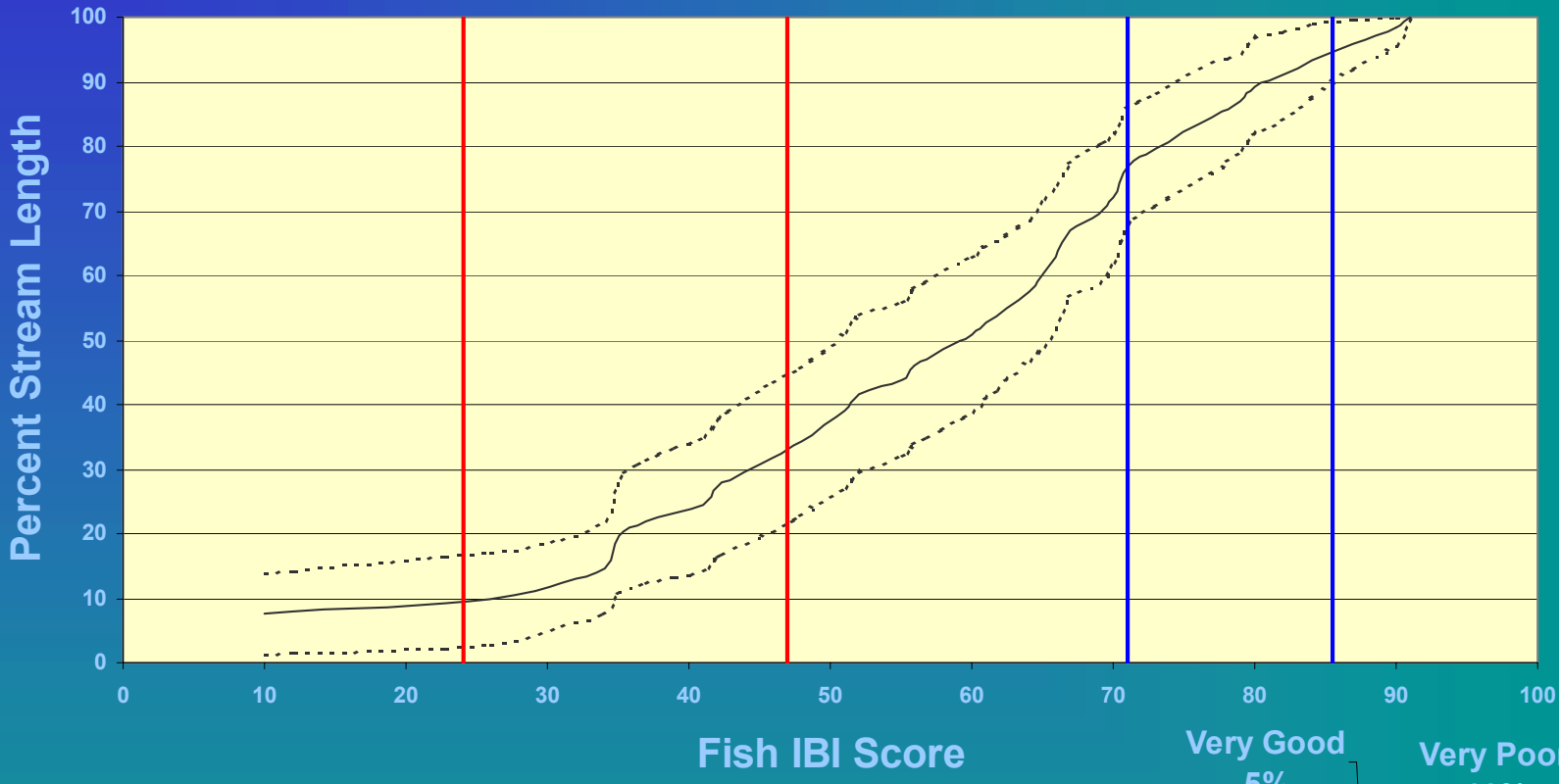
- Sites did not have to fail all metrics, but needed to fail at least one in each of these categories: a) DO / Total P / Total N; b) Sulfate; c) Embeddedness / Percent Fines; and d) Human Influence Index

- 10 Sites survived this process
  - 4 in the NW Great Plains
  - 6 in the NW Glaciated Plains.

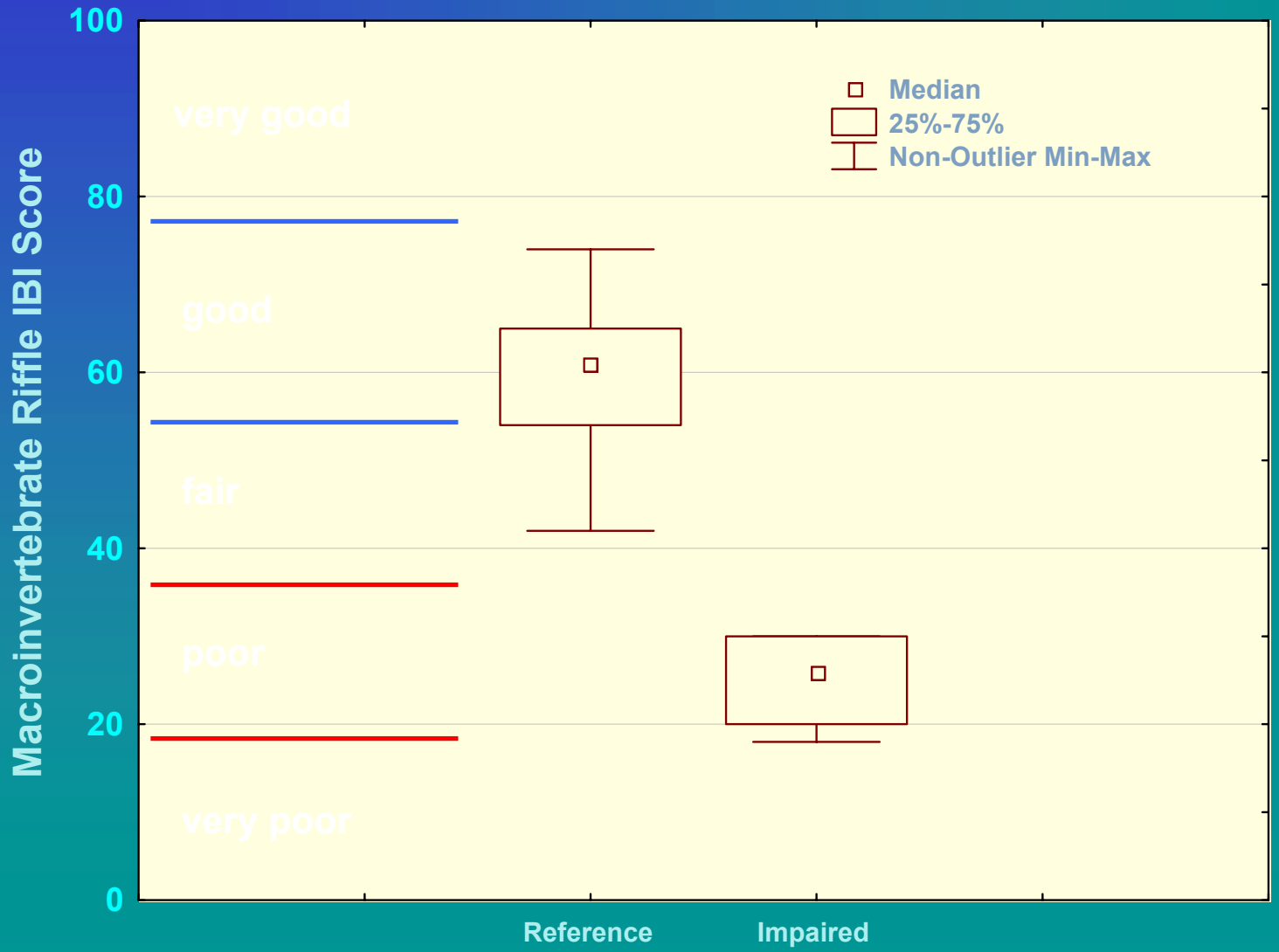
Fish IBI
"Reference" vs "Impaired"



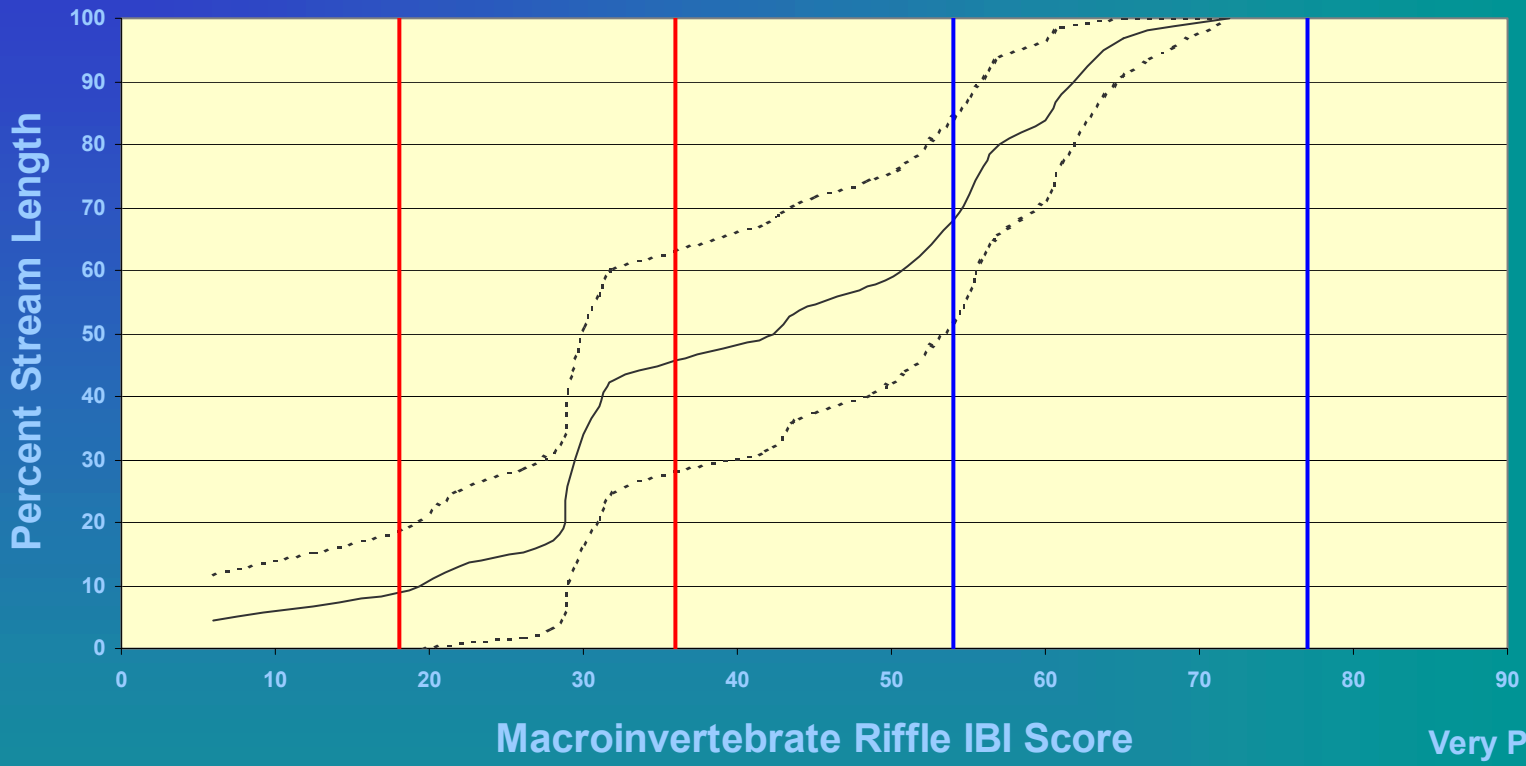
Condition Assessment Fish IBI

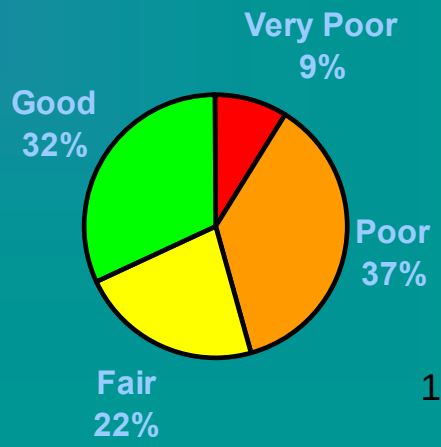


Macroinvertebrate IBI "Reference" vs "Impaired"



Condition Assessment
Macroinvertebrate IBI





Predictive Models

Based on a Large Number of Reference Sites, models are developed that provide Expected Values (E) for the location and setting of interest

Observed (O) Values at Monitoring Sites are Related to the Expected Values

The O/E ratio is of interest in evaluating the Monitoring Site with respect to its Expected Value

Predictive Model Assessments

Assessments are based on comparison of observed taxa with that predicted to occur. Biological condition is quantified by the ratio O/E, where E = Σ taxa probabilities of capture and O = Σ observed taxa predicted to occur.

O/E is simple to calculate once the probability of capturing (pc) each taxon is known. PC's are estimated from a statistical model that relates pc's of each taxon to natural environmental gradients (elevation, stream size, etc.).

Species	P_c	O
1	0.70	*
2	0.92	
3	0.86	
4	0.63	
5	0.51	*
6	0.32	
7	0.07	
8	0.00	
E	4.01	2

O/E = 2 / 4.01 = 0.50

The basic approach to modeling probability of captures (bugs) and estimating E was worked out in the early 1980's by freshwater biologists and statisticians in Great Britain

River InVertebrate Prediction and Classification System (RIVPACS)

*Moss, D., M. T. Furse, J. F. Wright, and P. D. Armitage. 1987. The prediction of the macro-invertebrate fauna of unpolluted running-water sites in Great Britain using environmental data. Freshwater Biology 17:41-52.

In the Western U.S., extensive reference site collection and RIVPACS development has been performed by Chuck Hawkins from the The Western Center for Monitoring and Assessment of Freshwater Ecosystems at Utah State University

Tolerance Values

- **Determination of the Sensitivity of Taxa to various environmental conditions**

Tolerance Value Determination Methods

- **Weighted average**
- **General Additive Models**
- **Logistic Regression**
- **RIVPACS**
- **Species sensitivity distributions**
- **Others**

- **Basic Question: Do the different methods give the same result, or comparable results?**

Example tolerance classifications

	TP	RBP	pH	SO4
Cheumatopsyche	T	S	S	I
Diplectrona		S	I	
Hydropsyche	T	S	S	
Syphitopsyche		S	S	
Lepidostoma	S	S	T	S
Pycnopsyche			I	
Dolophilodes		S	I	S
Polycentropus	S	S		I
Rhyacophila		S		S
Neophylax		S		I

T: tolerant, S: sensitive, I: intermediate

Ranking Stressors: Prevalence and Relative Risk

Based on work by

John Van Sickle
US EPA NHEERL
Western Ecology Division

Problem:

Assessing the relative importance of multiple stressors.

Previous Approach:

-- Compare regional prevalence of each stressor.

-- Define "Poor" condition for each stressor.

-- Estimate percent of stream miles in Poor condition.

-- Example:

Mid-Atlantic Highlands Assessment (MAHA) streams. (EPA/903/R-00/015)

Limitations of previous approach:

1) Stressor "importance" should also be based on the severity of its effects on biological endpoints.

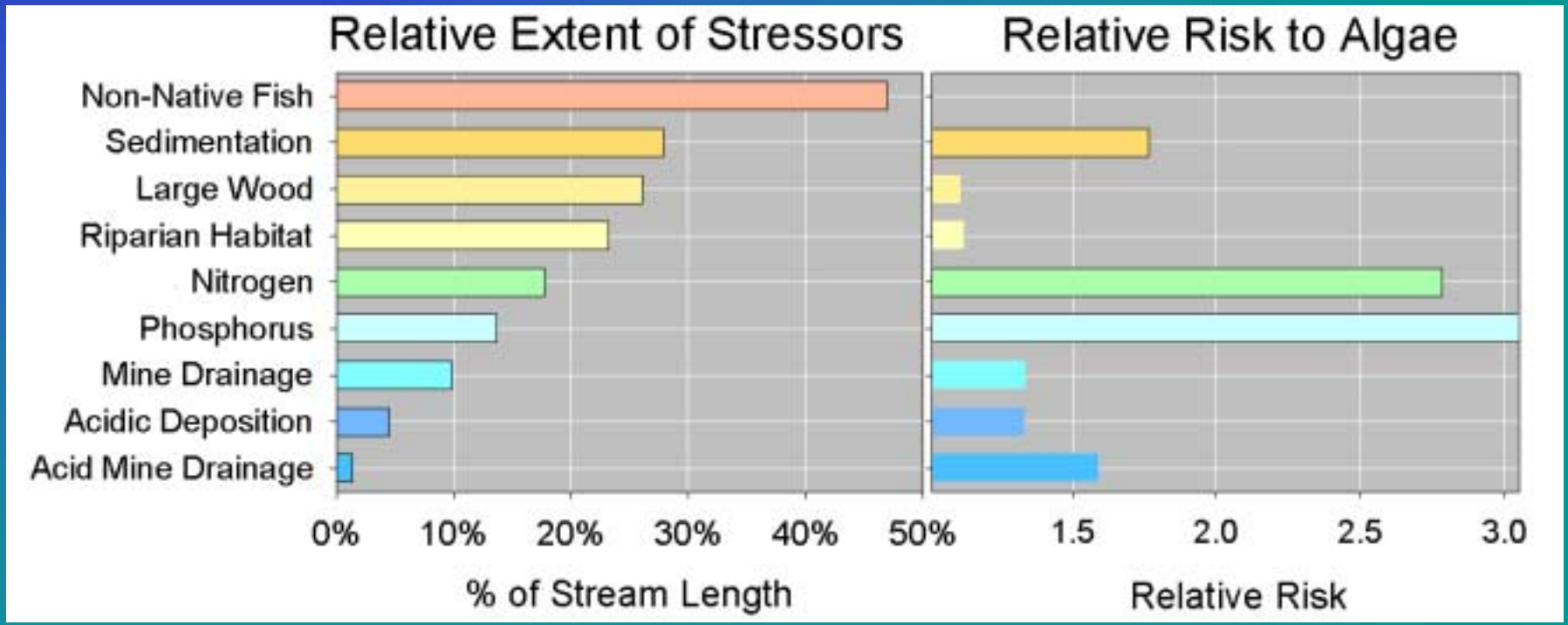
2) Definitions of "Poor" and "Good" condition may be arbitrary, either for stressors or endpoints.

To move forward:

1) Assess the strength of association between stressors and endpoints, as a surrogate for "effect severity".

2) Explore association methods for continuous, as well as class-based, stressors and endpoints.

EMAP Assessment - Example
Relative Risk of Stressors



Questions / Comments?